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APHOEBANTUS AND ITS RELATIVES EPACMUS AND EUCESSIA

(Diptera: Bombyliidae)[1]

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The subfamily Lomatiinae of the Bombyliidae includes some predominantly desert living forms, represented in the Western United States by three genera, *Aphoebantus*, *Epacmus* and *Eucessia*. Specimens are encountered singly, mostly as they alight on sandy places in the bright sun, but now and then some may be taken from flowers. Like most Bombyliidae the flies are wary and not easy to capture. Specimens must be transferred from net to killing bottle with careful handling and kept isolated until pinned because the body covering of tomentum and pile rubs off too easily and denuded specimens are almost worthless for identification. When dried, the tomentum may become discolored in spots by an exudation of grease and then light-colored scales may appear black and confuse the identification. In such cases it is well to look for a symmetrical pattern for scales are not likely to be greased the same on both sides of the body. Another aggravation is the facility with which heads snap off on handling, necessitating the cementing of the head back on the projecting neck.

The flies as a group have not been satisfactorily studied since Coquillett's review in 1894, and there is confusion as to the identity of some species. Many of the species are dimorphic, the sexes being markedly different in color of the frontal hairs, pruinosity of the head, color of the tomentum and pilosity of the body especially of the abdomen. Usually the males have a more silvery head, paler hairs, lighter tomentum and longer pile than the females.

For many of the species the extent of variation is uncertain. The color of the halteres is used in identification, but requires interpretation. Sometimes there are differences in the color of hairs, bristles and

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tomentum on specimens taken together.   The shape of the first posterior cell and the presence of a spur on the anterior branch of the third vein are useful indices, but are not infallible.   But in the main the characters used in the following tables will guide a specimen with little hesitation to its appropriate name.

The pygidia furnish important taxonomic characters, as can be seen from the illustrations of the species before me.   The drawings, showing the left aspect, are free-hand sketches, somewhat generalized, and are sometimes a composite based on several specimens.   I am grateful to Frances Ormerod for inking in the pencil sketches preparatory for the printer.   Usually the pygidia are in a closed condition, with the two sturdy dorsal harpagones seated on the ventral piece so that the deflexed apices are thrust within.   In diversity of shape and in the arrangement of hairs and tomentum the pygidia are sufficiently distinctive externally so that it is not necessary to relax them and pry open the occluded parts.   When ringent, the genitalia present a greatly altered appearance, with the deflexed hook at the end of the harpagones exposed, and the explanate edge of the ventral piece, which normally is infolded and hidden, now pushed out into view.

It is of interest to note that of the forty-one previously described species belonging to the three genera dealt with in this paper, nineteen were founded on one or two specimens and the same number on three or more, making a total of but 170 specimens.   Of the other three species there is no record of the number of specimens in the type series. With this precedent I make no apology for describing some striking species upon limited material.   The present study is based on over 800 specimens in my collection, augmented by about 130 from the Citrus Experiment Station of the University of California at Riverside, collected by P. H. Timberlake.   Unless otherwise noted the specimens under review were collected by myself.   I am particularly grateful to Frank H. Parker, who supplied many species from the desert regions of Arizona, where these flies are especially prevalent, and to John L. Sperry, whose interest in the arid country has netted many rare insects.

Many specimens key to species whose original locality is far distant from the place where the recent material was collected.   The inference is either than their distribution is more extended than would be expected or that the characters used in the keys are not exclusive enough to differentiate all the species.   For example, *Aphoebantus peodes* was originally described from Sonora, Mexico.   Cole reports it from Hood River, Oregon, and I have taken at 6250 feet altitude in the San Bernardino Mountains in California specimens that fully agree with Osten Sacken's description.   It is therefore possible that some of the many species which I think I have recovered, which were taken far from their original home, are incorrectly determined, although agreeing well with the descriptions on which they were established.   Comparison with the types holds the answer, but of course such perplexities are not peculiar to these Bombyliids but extends throughout the province of taxonomy.

The earliest species described for this group were *Leptochilus* (now *Epacmus*) *modestus* and *Aphoebantus cervinus*, which Loew published in

1872. These two species came from Texas, the easternmost extension of the species of this group. Osten Sacken, in the Western Diptera, next described *Triodytes* (now *Aphoebantus*) *mus*, a species now reported from Utah, California, Arizona, Sonora and Baja California. In the Biologia Centrali-Americana Osten Sacken added *A. carbonarius* from Washington, Kansas and Sonora, *rattus* from Texas, *conurus* from California and three species from Sonora. Bigot, 1892, added a problematical species, *Epacmus rufolimbatus*, from California. Our principal knowledge of this group has been contributed by Coquillett, who in a series of four papers published from 1886 to 1894 added twenty-five species, all from Southern California. Since then Cresson, 1919, published *Epacmus pallidus* from Texas and Cole in 1921 added *Epacmus nitidus* and *Aphoebantus borealis* from Oregon, and in 1923 added *Aphoebantus argentifrons* and *marginatus* from Baja California. In the latter paper Cole reported nine of the previously described species as occurring in Lower California. Aside from the localization in the Southwest, *Aphoebantus* is recorded from the Mediterranean area, India and Ceylon, and similar forms are reported from China.

GENERIC DISTINCTIONS

Aphoebantus was established by Loew on the female of *cervinus*. Loew emphasized the abruptly slender styliform prolongation of the third antennal joint, presence of pulvilli, a spur on the fifth vein entering the discal cell, another spur on the branch of the third vein, and a bristle at the apex of the hind metatarsi, the last four characters now known to have no generic significance. Osten Sacken, mislead by the stress on the pulvilli, formed the genus *Triodytes* for a new species, *mus*. In the Biologia Centrali-Americana Osten Sacken placed his genus as a synonym of *Aphoebantus*.

The genus *Eucessia* Coquillett was established in 1886 on one species, *rubens* Coquillett, characterized by the third antennal joint being somewhat oval, scarcely longer than wide and tapering to a blunt tip. The genotype, which is a distinctive species, has a retreating face, bare except on the oral margin, proboscis not projecting, pulvilli present, eyes of male quite widely separated on the front and pygidium very large and greatly dilated below. Coquillett in 1891 added *Aphoebantus rattus* Osten Sacken to his genus, thus modifying the concept, in that the third joint of the antennae of *rattus* is elongate conical, the face less retreating, the pulvilli minute, and the labellae are narrow. Osten Sacken mentioned that in these structures his species approached *Epacmus*. Curran still further changed the limits of *Eucessia*, for in his Manual the genus is defined as having the antennae placed far from the oral margin, and the figure of an undescribed species indicates an absence of the characteristic pile of the anterior parts of the head. In *rubens*, as well as in all the other species treated in the present paper, the antennae are located well below the midpoint between the ocelli and the mouth opening. If emphasis be restricted to the oval shape of the third antennal joint the genus is unique in the Lomatiinae. But by including those forms with elongate triangular joint the species merge into *Aphoebantus* and the validity of the genus is lost.

Epacmus Osten Sacken, originally given the preoccupied name

Leptochilus by Loew, was separated from *Aphoebantus* in having a projecting face, elongate proboscis with slender labellae, no spur on the third vein and pulvilli absent. Osten Sacken noted in the Biologia Centrali-Americana that the spur on the third vein has no generic importance, and Coquillett (1894) and Williston (1901) discarded the size of the pulvilli.

The difference between the three genera are thus elusive. Coquillett at first located his species *concinnus, fumosus, pellucidus* and *transitus* in *Epacmus* and later transferred them to *Aphoebantus*. *Aphoebantus litus* Coquillett is much more closely related to *modestus* Loew, the genotype of *Epacmus*, than to any of the other species placed in *Aphoebantus*. Coquillett placed his species *litus* in *Aphoebantus* but assigned his *nebritus* to *Epacmus*, although the two are structurally much alike, differing mainly by the color of the scales of the abdomen. *Epacmus tomentosus*, n. sp., is almost identical with *Aphoebantus pellucidus* Coquillet, but has slender corneous labellae, whereas in *pellucidus* the labellae are short and fleshy. What I take to be *rattus* is even intermediate between *tomentosus* and *pellucidus*. The new species *sperryorum*, on antennal structure would classify in Coquillett's emended *Eucessia*, but in its vestiture and the structure of its remarkable pygidium is so close to *Aphoebantus abnormis* Coquillett that the similarity is greater than could be accounted for by homoplasy. The new species *connectans* has the antennal structure of *Eucessia*, the facial contour of most of the species of *Aphoebantus*, but the proboscis is long and its labellae are slender as in typical *Epacmus*.

Because the three genera are so interlocked they do not indicate phyletic segregation. The antennal form in *Aphoebantus* ranges from onion-shaped, with cylindrical elongate styliform process arising from a bulbous base, to elongate conical, and in those species having the wider tapering apex to the third joint the shape is influenced by the degree of collapse upon drying. After eliminating the pulvilli, spur on the third vein, spur in the lower part of the discal cell, recession of the face and antennal formation as useless generic characters there is nothing left to distinguish the expanded *Eucessia* from *Aphoebantus*, and in the present paper *Eucessia* is restricted to the original species with its short ovoid antennal joint. The residual differences between the three genera may then be expressed as follows:

1. Proboscis projecting beyond the mouth-opening, the labellae typically elongate, narrow, somewhat pointed, and corneous; third antennal joint typically with bulbous base and slender styliform projection; face rather protruding below, the cheeks typically narrow and the mouth-opening elongate, horizontal and well defined anteriorly (in *connectans* the face rounding into the oral margin)..............................**Epacmus**
   Proboscis not or scarcely projecting beyond the mouth-opening, the labellae more or less broad and fleshy; cheeks broader, the mouth-opening wider and rounding into the face anteriorly; face retreating, or at most vertical...2
2. Third antennal joint much longer than depth at base, the base more or less bulbous, typically constricted into a slender cylindrical styliform process, but often lanceolate or elongate conical, the apical part appearing shrunken instead of abruptly styliform; face usually pilose to antennae...**Aphoebantus**
   Third antennal joint not much longer than wide, rather widely oval, not constricted beyond middle but narrowed just before apex; face bare above,...**Eucessia**

Genus **Epacmus** Osten Sacken

Epacmus is a useful though not a natural genus. The species grouped here show the same divergencies that occur in *Aphoebantus*. In both genera the scutellum ranges from wholly tomentose to apically polished and may even be bilobed with a concentration of tomentum on the median sulcus. The thorax and scutellum may have bristles or may be devoid of them. The third antennal joint may have a long thin apical spindle attached to an onion-shaped base, or may be more or less elongate conical. The proboscis varies in length, though the extreme protrusion is not matched in *Aphoebantus*. The femora have hairs or bristles, and the middle femora of both genera show a tendency to develop appressed pubescence apically on the posterior surface. The branch of the third vein shows the same tendency to develop a spur. The face may or may not recede. Such parallelisms indicate that one or the other genus is polyphyletic. On a different basis of classification the species with sulcate scutellum could be grouped together, or those with receding face, or those with the styliform tip to the antennae, or those lacking scutellar bristles, etc., and perhaps relationships would then be as well indicated as to rely on the structure of the labellae to show the course of evolution.

KEY TO THE SPECIES OF EPACMUS[3]

1. Proboscis as long as thorax and abdomen; abdomen more or less shining, the sides and apex fulvous; anterior crossvein clouded.......**rufolimbatus**
   Proboscis not longer than the thorax, usually much shorter; abdomen black in ground color; wings without central mark...................... 2
2. Scutellum posteriorly devoid of scales except an apical patch; face with projecting cluster of rather stiff hairs in front of oral opening; third antennal joint usually with abruptly slender styliform process from a bulbous base; pygidium tomentose (except *pallidus*); frontal hairs of female wholly or in part black..............................:..................... 3
   Scutellum wholly dull and tomentose; third antennal joint tapering; pygidium not tomentose (male of *labiosus* not known); frontal hairs of female pale; abdomen without black scales; costal setulae yellow at root of wing..11
3. Third antennal joint with styliform process longer than the basal bulb; eyes of male contiguous or nearly so; abdomen with patches or bands of black scales; palpi black or blackish................................:......... 4
   Third antennal joint with the apical process shorter than the conical base or tapering; abdomen with no black scales; palpi pale.................. 9
4. Lower center of face with a brush of coarse black hairs not extending laterally beyond bases of antennae, otherwise bare..................... 5
   Hairs of face of male at least in part white or yellowish, of female often darker but not densest and longest on the median line...................,......... 6
5. Lower rim of face luteous, concolorous with cheeks and oral cavity; hairs of front of male mixed pale yellow and black, of female all black; pygidium large and globose; legs blackish....................**ponderosus**
   Face wholly black, cheeks and oral cavity ivory white; hairs of front of male all pale yellow, of female black; pygidium small; knees, tibiae and tarsi yellowish...**morsicans**
6. Upper claspers (harpagones) ending in a deflexed reddish cirrus; last sternite without long hairs; scutellum somewhat sulcate; face hairy almost to eyes; branch of third vein not appendiculate.....................**cirratus**
   Harpagones not cirrate but with loose hairs; sides of face bare............ 7

[3]The following species included in the key are not discussed in the text of this paper: *nitidus* Cole, *pallidus* Cresson, and *rufolimbatus* Bigot.

7. Viewed from in back the lower part of pygidium presents two large velvet-black oval disks; last sternite devoid of long hairs; center of face with a brush of projecting honey-yellow hairs, lower edge of face not sharply black; scutellum sulcate; third vein without spur..............**clunalis**
    The oval flaps at rear of pygidium not contrasting; last sternite of male with many long hairs especially on sides; hairs of face decumbent and white... 8
8. Scutellum not at all sulcate and without apical patch of scales; branch of third vein appendiculate; face sharply black below...............**litus**
    Scutellum medially emarginate and with apical tomentose spot; branch of third vein not appendiculate; face not sharply black below, merging into the yellow cheeks....................................**modestus**
9. Abdomen with some brown tomentum................................10
    Abdomen shining black, with only yellowish and white tomentum, denser at bases of segments, pygidium yellowish below; eyes of male separated by width of ocellus; styliform process of antenna as long as base; scutellum not emarginate; veins mostly black...........................**nitidus**
10. Abdominal segments 2 to 5 with whitish tomentum, each with a fascia of brown tomentum; eyes of male contiguous; scutellum bilobed; third antennal joint tapering; veins yellow; all bristles pale.............**pallidus**
    Abdomen covered with brown tomentum, white at base; eyes of male separated one-third width of ocellar triangle; scutellum more or less emarginate...**nebritus**
11. No bristles on rear of thorax and scutellum; body heavily coated with ochreous tomentum; third vein with spur. (If labellae are short and fleshy, see *Aphoebantus pellucidus*, couplet 46.)........................12
    Bristles present on thorax and scutellum; third vein without spur; legs mostly yellowish, but black in male of *connectens*......................13
12. Eyes of male contiguous, abdomen clavate, pygidium massive; face and cheeks mostly yellow...................................**tomentosus**
    Eyes separated; abdomen not enlarged caudally, the pygidium small; face and cheeks black, only the oral rim yellow...............**pulvereus**
13. Face conical, the face, most of front and basal joints of antennae yellowish; veins light yellow...**labiosus**
    Face strongly receding; front and face of female with abundant whitish pubescence; head and antennae black; veins of posterior part of wing blackish; hind femora with long hairs below; proboscis much extended; eyes of male widely separated.............................**connectens**

Epacmus cirratus, n. sp.
Figure 4

Male.—Length 9 mm.   Eyes contiguous for one-sixth the distance between the front ocellus and the antennae: front silvery-pruinose, the white pile in divaricate rows following the bare orbits, tomentum dense, white, located in the pilose area; face white-pruinose merging into the yellow oral margin and cheeks, the white pile decumbent, with the hairs at the beard longer, in profile the face distinctly projecting below; ocellar triangle black, with black hairs; occiput silvery along the upper orbits, its pile and tomentum white; first joint of antennae white-pollinose, with white hairs and tomentum, styliform process of third joint slender, cylindrical and one and one-half times as long as the globose base; proboscis projecting beyond the antennae, the labellae very narrow and about one-third as long as the base; palpi longer than the labellae, slender, black.   Ground color of thorax dull gray, the tomentum and pile of the front part whitish, posterior hairs black, bristles yellow with black ones admixed on posterior callosities; scutellum black, the base and median line with whitish tomentum, posterior portion shining, apex slightly emarginate, scutellar hairs black; pleura and
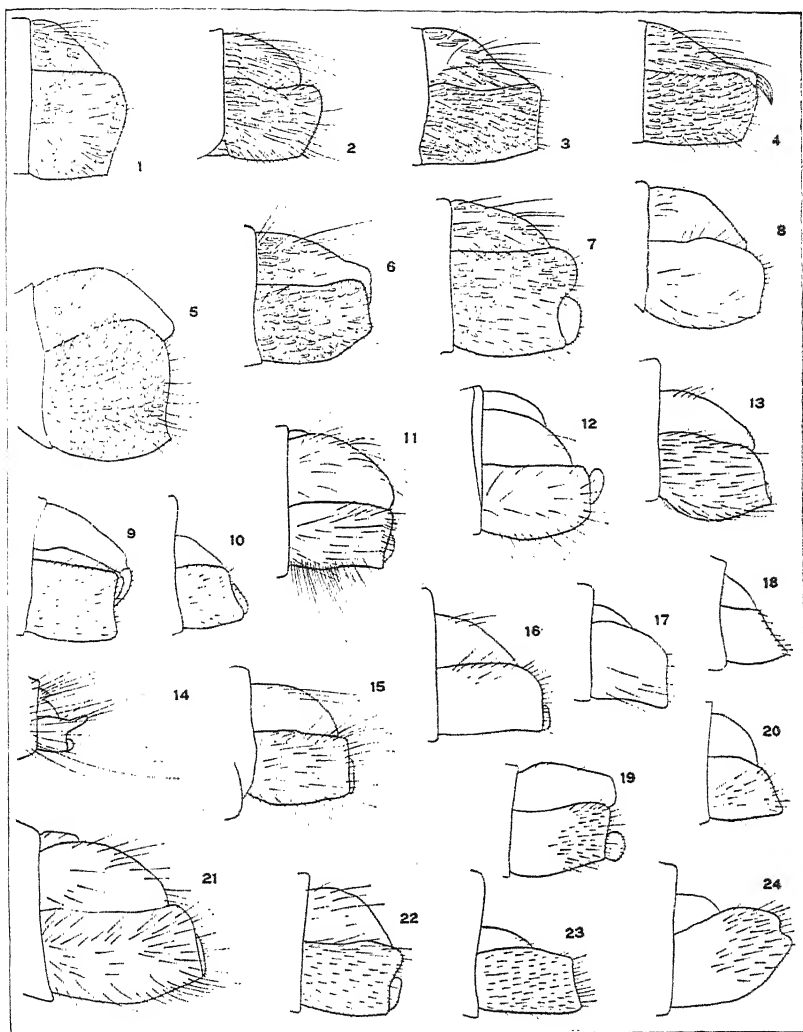
Left side of pygidia of *Epacmus* (Figures 1-10) and *Aphoebantus* (11-24).
1, *Epacmus modestus* Loew. 2, *E. litus* Coquillett. 3, *E. clunalis*, n. sp. 4, *E. cirratus*, n. sp. 5. *E. ponderosus*, n. sp. 6, *E. morsicans*, n. sp. 7, *E. nebritus* Coquillett. 8, *E. tomentosus*, n. sp. 9, *E. connectens*, n. sp. 10, *E. pulvereus*, n. sp. 11, *Aphoebantus desertus* Coquillett. 12, *A. cyclops* Osten Sacken. 13, *A. balteatus*, n. sp. 14, *A. mus*, Osten Sacken. 15, *A. eremicola*, n. sp. 16, *A. pellucidus* Coquillett. 17, *A. contiguus*, n. sp. 18, *A. fumosus* Coquillett. 19, *A. contiguus separatus*, n. var. 20, *A. leviculus* Coquillett. 21, *A. peodes* Osten Sacken. 22, *A. timberlakei*, n. sp. 23, *A. vulpecula* Coquillett. 24, *A. vasatus*, n. sp.

coxae cinereous, the hairs and scales almost white. Abdomen cylindrical, narrowed midway, largely deep-yellow-tomentose, first segment with complete apical fringe of long white scales, segments 2 to 6 each with a dorsal patch of white scales and with basal band of black tomentum, the fasciae becoming less evident on posterior segments, last tergite and the venter closely white-tomentose, hairs of abdomen long, white, dense on sides of first segment; pygidium of moderate size, the ventral piece white-tomentose like the sternites, its hairs scattered, upper claspers almost black, basally with long castaneous hairs and elongate luteous scales, the apex with a downward-curved dense cluster of reddish setae at the base of which is a white-pruinose ring. Femora blackish in ground color, thickly overlaid with white tomentum, the knees, tibiae and tarsi reddish yellow, all bristles pale, middle femora with three bristles in front near the middle and a weak fringe on the apical half behind, hind femora with rather strong bristles below. Wings hyaline, subcostal vein yellow, other veins brownish, hairs at root of costa yellow becoming admixed with black, first posterior cell fusiform, the apex intermediate in length between the anterior and posterior crossveins, sections of the fifth vein proportioned 2 : 3; halteres dusky yellow, the knob brownish, except the flavous apex.

Holotype: New Mexico, date, locality and collector not known.

Epacmus clunalis, n. sp.
Figure 3

Male.—Length 7 mm. Eyes contiguous two-fifths the distance to the antennae; front white-pruinose, its pile and tomentum forming a triangle above the antennae, orbits bare; face projecting below, pruinose, bare on the sides; cheeks yellowish; upper occiput satiny white along the orbits, hairs short and whitish, ocellar triangle and its hairs black; base of antennae slightly cinereous, the third joint with the slender styliform process one-fourth longer than the globular bulb; labellae of proboscis projecting beyond mouth-opening, four times as long as deep, pointed, palpi blackish. Thorax dull grayish black, the rear of the posterior calli and scutellum except base polished black, scutellum strongly bilobed, tomentum, hairs and anterior bristles of notum pale yellowish, posterior bristles and those of scutellum black, tomentum of scutellum dense on the lateral angles, median line and apical spot; pleura dull cinereous, hairs and scales whitish. Tomentum of the coarctate abdomen mostly yellowish, first segment with white fringe, second segment with basal band of black scales, the next four segments with sublateral spots of black scales, diminishing behind; pygidium as long as the three preceding segments, its scales whitish, those on distal half of the harpagones fulvous, harpagones subshining blackish, the downward curved ends rufous, distal half of harpagones with conspicuous reddish setae. Femora brownish, with white scales, tibiae and tarsi yellowish, hind femora with a few bristles and hairs. · Veins brown, the anterior veins yellow at base, costal setulae black, first posterior cell at apex equal to the posterior crossvein, sections of fifth vein 1 : 2; knob of halteres brownish, stalk paler.

Female.—Front three-fourths as wide at ocelli as at antennae, subshining black above becoming cinereous below, the lower orbits narrowly
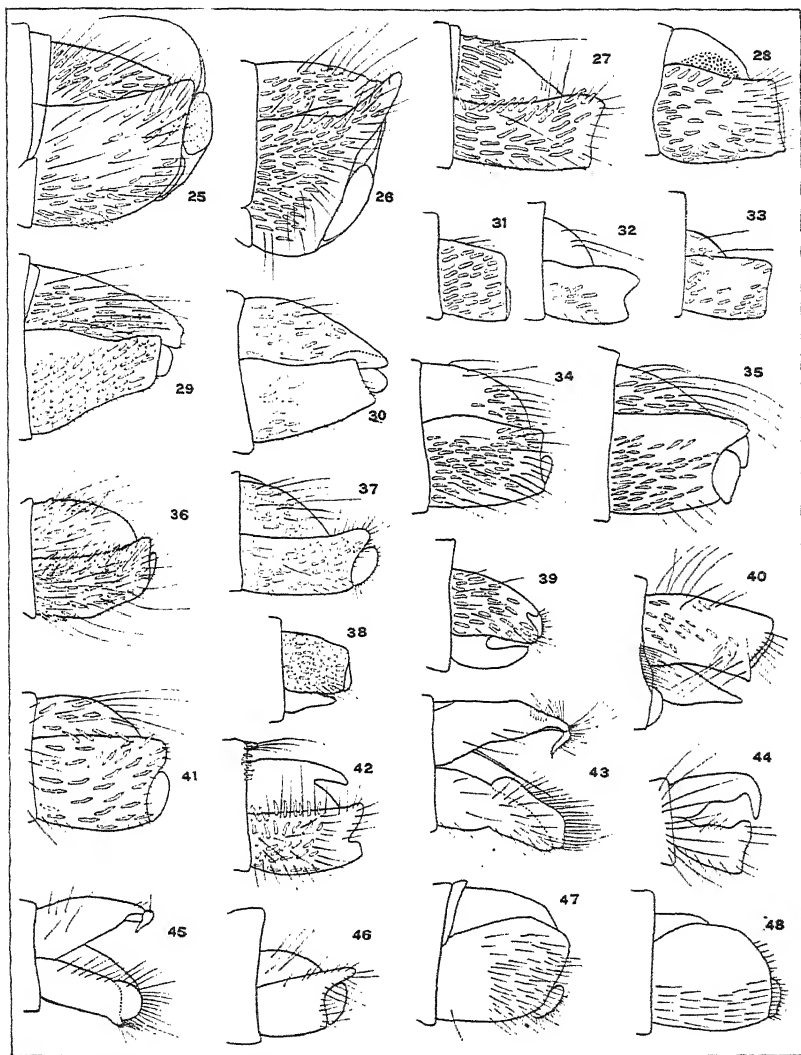
Left side of pygidia of *Aphoebantus*. 25, *A. abnormis* Coquillett. 26, *A. sperryorum*, n. sp. 27, *A. ursula*, n. sp. 28, *A. marcidus* Coquillett. 29, *A. conurus* Osten Sacken. 30, *A. parkeri*, n. sp. 31, *A. obtectus*, n. sp. 32, *A. varius* Coquillett. 33, *A. vittatus* Coquillett. 34, *A borealis* Cole. 35, *A. mormon*, n. sp. 36, *A gluteatus*, n. sp. 37, *A bisulcus* Osten Sacken. 38, *A. micropyga*, n. sp., invert. 39, *A. catenarius* n. sp., invert. 40, *A. inversus*, n. sp., invert. 41, *A. halteratus*, n. sp. 42, *A. scalaris*, n. sp. 43, *A. hians*, n. sp. 44, *A. transitus* Coquillett. 45, *A. tardus* Coquillett, expanded. 46, *A. tardus*, closed. 47, *A. interruptus* Coquillett. 48, *A. arenicola*, n. sp.

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satiny and bare, pile of front black, the loose tomentum whitish; upper face cinereous, the stiff projecting mystax yellow, with a few black hairs at center.   Abdomen conical, the tomentum much as in the male but the hind margins of the segments fringed with whitish scales and the scales behind the black spots more fulvous.

Types: Three males and three females, Ritzville, Washington, June 16, 1920 (R. C. Shannon) and Almota, Washington, May 25, 1913. The primary types were selected from the Ritzville lot.   *Clunalis,* Latin, pertaining to the hinder parts.

Epacmus connectens, n. sp.
Figure 9

Female.—Length 10 mm.   Head white-pollinose, vertex cinereous, front, face and occiput completely covered with short yellow pile and dense tomentum, the latter sparser between the antennae and eye, hairs and tomentum of front sometimes golden, oral margin black; basal joints of antennae cinereous, with a few pale hairs, third joint three times as long as deep; proboscis slender, extending much beyond the antennae, the labellae thin and pointed, five times as long as wide and one-third the basal portion, palpi dark fuscous.   Thorax and scutellum dull gray, the tomentum, short pile and bristles pale yellow; pile of pleura whitish.   Abdomen with pale yellow tomentum and short hairs, the pile of the first segment longer and its apex with an inconspicuous fringe of white hairs, incisures reddish, more broadly so posteriorly and on the venter, apical fimbria golden.   Legs reddish, the front femora in part blackish, tomentum whitish, femora without bristles, the hind pair with twelve or more hairs beneath, all tibiae with evident spicules, spur of hind metatarsus strong.   Wings hyaline, anterior veins luteous, others fuscous, no spurs, all setulae of costa pale, apex of first posterior cell three-fourths as long as the posterior crossvein, sections of fifth vein 1 : 4 to 1 : 3; knob of halteres flavous, stalk somewhat brownish.

Male.—Length 7 mm.   Front, face and broad upper occiput argenteous, all pile and tomentum white, abdomen pilose; legs blackish, the knees narrowly reddish.   Face swollen in front, the pile fine and short, front without pile and tomentum along the orbits and in the middle below; eyes separated as widely as the posterior ocelli; upper occiput deeply gouged behind the ocellar triangle; proboscis very slender and elongate, twice as long as the head, the labellae as long as the antennae and six times as long as broad.   Pygidium smaller than the last segment, ventral plate pruinose, not tomentose, its upper angles sharp, harpagones small, blackish, not hairy, the deflexed apex spiniform. Tibial spines weak.

Holotype female: Sabino Canyon, near Tucson, Arizona, April 27, 1948.   *Allotype male:* Four miles east of Edom, near Palm Springs, California, April 17, 1937, on indigobush, *Dalea schottii* (P. H. Timberlake; Citrus Experiment Station).   *Paratypes:* Six females, Aztec and Gila Bend, Arizona, April 14, 1938 (F. H. Parker); near Edom, California, March 28, 1936, and April 10, 1937, on creosotebush, *Larrea divaricata* (P. H. Timberlake; Citrus Experiment Station).

This species is markedly different from the others grouped in *Epacmus* in the contour of the face but differs from the species of *Aphoebantus* in having the proboscis elongate and thin with long narrow chitinized labellae.

Epacmus labiosus, n. sp.

Female.—Length 7.5 mm.   Head yellow except the black vertex and occiput, the front and face mostly golden pruinose, with yellow tomentum and short pile, face strongly projecting, widely pilose below; occiput with white scales which become golden above; first two antennal joints yellow, with a few pale hairs, third antennal joint black, lanceolate, nearly three times as long as deep, the style distinct; proboscis attaining end of the face, the labellae about four times as long as wide, with upturned apex, palpi linear, half the length of the proboscis, yellowish. Mesonotum and scutellum dull gray, the tomentum and hairs whitish, bristles yellowish; pleura cinereous, tomentum and hairs white. Abdomen black, with ventral incisures reddish, hairs and scales white, apical fimbria pale yellow.   Legs yellow, the trochanters with apical dark dot, posterior femora and all tibiae with usual spines.   Wings hyaline, veins flavous, setulae at root of costa pale, first posterior cell at margin equal to the length of the posterior crossvein, sections of the fifth vein proportioned 1 : 3, no adventitious veins; halteres pale yellow.

Holotype: Lynndyl, Utah, August 2, 1918 (Geo. E. King). *Labiosus,* Latin, having a swollen lip.

Epacmus litus Coquillett
Figure 2

This is a common species in the Southwest.   I have taken it at Riverside, California, elevation 850 ft., and in the San Bernardino Mountains above 7000 feet.   Frank H. Parker has sent me specimens from the White Mountains, Arizona.   Nearly all the specimens were captured in September and October as they alight on bare sunny spots on sandy ground, though an occasional specimen is attracted to the brilliant yellow flowers of rabbitbrush (*Chrysothamnus*) or matchweed (*Gutierrezia*).

The pollen and hairs of the front and face of the male are very delicate, short and pure white; the ventral piece of the pygidium is short, about the length of the preceding segment.

Epacmus modestus Loew
Figure 1

I have taken a male at Lordsburg, New Mexico, May 1, 1942, and a female at Marfa, Texas, April 28, 1942, that agree well with Lowe's description of *modestus*.   Curran has figured the head of the male in his Manual, page 198, fig. 59.

Epacmus morsicans, n. sp.
Figure 6

Male.—Length 8 mm.   Eyes contiguous one-third of the way to the antennae, ocellar triangle black, with three small black hairs; front

silvery-golden, pile and tomentum concolorous, the hairs parallel with the bare orbits; face projecting on the lower shining black part, white-pruinose below antennae, bare except the tuft of black setae at the mid-oral margin; the roof of the oral cavity continuing the black of the face medianly but the sides ivory white like the cheeks; occiput and its pile and tomentum of same tone as the front, upper orbits with satin sheen; proboscis very slender, strongly projecting, the labellae narrow, pointed and about one-fourth as long as the basal part of the proboscis, palpi delicate, not longer than labellae, blackish. First antennal joint cinereous, with a few pale hairs, styliform part of third antennal joint very slender, about twice as long as the basal bulb. Thorax dull gray, tomentum, hairs and bristles light yellow, posterior callosities and scutellum shining, the latter with yellow tomentum at the base and at the emarginate apex, its bristles dark brown; pleura and coxae cinereous, the tomentum, hairs and bristles whitish. Abdomen rather coarctate, dull gray, the tomentum mostly deep yellow above, becoming white laterally, first segment with fringe of long white tomentum and with abundant white hairs on the sides, last tergite covered with white tomentum, second to fourth segments with diminishing basal bands of black tomentum; harpagones shining black but with rufous deflexed bare tip, their base with white scales and a few brownish setae. Femora mostly black, coated with white scales, the knees, tibiae, and tarsi reddish, bristles yellowish; middle femora with one bristle at middle below and with a few hairs on apical half behind, hind femora with a few bristles. Wings hyaline, veins brownish, the subcostal vein luteous, setulae at base of costa black, branch of third vein and underside of the discal cell angulate and each with short spur, first posterior cell as wide in the margin as the length of the posterior crossvein. Stem of halteres yellow, knob slightly brownish.

Female.—Front black, increasingly white-pollinose and tomentose toward antennae, its hairs scattered, short black; upper occiput blackish. Abdominal segments mostly black-tomentose, the incisures with wide fasciae of white scales, suggestive of *Aphoebantus marginatus*, hairs short, venter densely and completely coated with white scales, apex of the abdomen fimbriate with golden hairs. Wings without the spurs.

Holotype: Globe, Arizona, October 9, 1935. *Allotype:* Wilcox, Arizona, September 14, 1935. *Paratype:* Female, Ray, Arizona, September 20, 1936. All were collected by Frank H. Parker. *Morsicans,* Latin, with the lips pressed together.

Epacmus nebritus Coquillett

Figure 7

Unlike the late-season *litus,* this species is to be found during March to May. Professor Timberlake has taken it at Riverside, California, on *Chaenactis glabriuscula,* and F. H. Parker has furnished a specimen from Ajo, Arizona.

Besides the characters mentioned in the table the following may be helpful for identification: oral margin of face yellowish, pollen and hairs of front and face yellowish, coarser than in *litus:* labellae compressed, elongate ovoid, less than three times as long as deep; the barrel-shaped ventral piece of the pygidium as long as the two preceding segments together.

Epacmus ponderosus, n. sp.

Figure 5

Male.—Length 7.5 mm. Eyes contiguous two-fifths the distance to the antennae; front argenteous, orbits bare, tomentum whitish: face satiny white above, with shining black middle band having a median brush of nearly porrect stiff black hairs, the oral margin entirely luteous like the buccal cavity: occiput cinereous, the upper orbits argenteous, tomentum white; base of antennae cinereous, with very few short white hairs above, third antennal joint with small bulb about half as long as the slender styliform apical part: proboscis projecting to the tip of the antennae, labellae slender, about one-fourth as long as the base, palpi linear, blackish. Thorax dull gray, tomentum whitish, anterior pile whitish, discal hairs black; rear of posterior calli and the scutellum shining black, each with a lateral group of white scales, base and the emarginate apex of the scutellum provided with pale yellow scales: pleura and coxae cinereous, the scales and hairs whitish. Abdomen strongly coarctate, ventral segments suppressed; first segment cinereous, with apical fringe of long white scales and with lateral whitish hairs; middle segments with usual arrangement of tomentum in basal black bands, lateral and apical white and intermediate yellowish scales; pygidium globose, as long as the preceding six segments together, harpagones very robust, piceous, not shining, with scattered long ochreous scales and loose blackish hairs, the fuscous apex bluntly reflexed, ventral piece broadly barrel-shaped, piceous, with elongate whitish scales, scattered reddish hairs which become denser toward the apex and with lateral apical yellowish inflexed fringe, the pair of caudal velvety pads furnished with vertical hairs above. Legs blackish, tomentum white, the knees narrowly brownish, the posterior femora and the tibiae with usual bristles. Wings hyaline, veins brown, branch of third vein and underside of the discal cell with short spur, apex of first posterior cell slightly shorter than the posterior crossvein, sections of the fifth vein proportioned 1 : 2, costal setulae all black; halteres with luteous stalk and apex, the remainder of the knob brownish.

Female.—Lower front slightly white-pollinose, frontal pile short and black, tomentum close, pile yellowish. Abdomen not coarctate, first segment with white fascia, remaining segments with basal bands of black tomentum occupying about one-third the segments, followed by fulvous tomentum, the incisures narrowly white-tomentose, last sternite shining, devoid of scales.

Holotype: Globe, Arizona, October 9, 1935. *Allotype:* Pinal Mountains, Arizona, October 15, 1948. *Paratypes:* Six males and one female, taken with the allotype. All collected by Frank H. Parker.

Epacmus pulvereus, n. sp.

Figure 10

Male.—Length 7 mm. Densely coated with fine yellow tomentum becoming white on head, sides and front of thorax, underside of abdomen and legs. Front and upper occiput argenteous, orbits bare, rest of front with triangular dense covering of pure white scales and with white pile admixed; ocellar triangle black, eyes separated two-

thirds the width of the front ocellus; face somewhat projecting, upper half bare, pile white and extending to the eyes, the hairs of the anterior margin slightly yellow, coarse, almost scale-like; base of antennae with only microscopic hairs, third joint rather conical, the distal half more tapering; proboscis not projecting, palpi pale fuscous, oral margin yellowish along posterior two-thirds. Lateral bristles of thorax very small, not noticeable; pleura and postalar declivities cinereous. Abdomen short and thick, lateral pile short; ventral scales sparse; pygidium not tomentose. Femora piceous, rest of legs dark fuscous, hind femora setose below, hind metatarsus without bristle. Anterior and basal veins luteous, distal veins becoming blackish, costal setulae pale, first posterior cell two-thirds as wide at apex as at the middle, sections of fifth vein 1 : 3: halteres ivory white.

Female.—Front half as wide at ocelli as at antennae, black above becoming white-pollinose below, tomentum yellow, dense, almost attaining the eyes, pile short, scattered, pale yellow. Abdomen without pile except on first segment, anal opening circular, the inflexed fimbria very short and black.

Types: A pair taken at Wellton, Arizona, April 14, 1938, by Frank H. Parker. *Pulvereus*, Latin, covered with dust.

Epacmus tomentosus, n. sp.
Figure 8

Male.—Length 7.25 mm. Densely coated above with short appressed yellow tomentum becoming tawny on abdomen; posterior part of thorax and scutellum with very short hairs in lieu of the usual bristles. Front, face and upper occiput argenteous; center of front with short white pile and yellowish tomentum, leaving the orbits glistening; face nearly vertical, upper half bare, the lower hairs short, white and extending from eye to eye; eyes contiguous one-fourth of the way to the antennae; rear of occiput with only minute pile, ocellar triangle black, its hairs microscopic; basal joints of antennae cinereous, third antennal joint quite uniformly tapering, nearly three times as long as deep, mouth-opening posteriorly yellowish, proboscis not surpassing the face, labellae about one-third the basal portion, three times as long as wide, rather pointed, palpi fuscous. Thorax and scutellum opaque gray, the individual scales wider on three anterior vittae, rear of the notum and on scutellum; discal hairs forming a short pale yellow coating, longer along the anterior edge; pleura densely cinereous, the scales and hairs white. Abdomen with basal segment, sides and the narrow venter cinereous, pile whitish, dense on the first segment; pygidium massive, harpagones broad, blackish with brown thick tip, cinereous in ventral view, the hairs basal, sparse and short; ventral piece broad, as long as wide, cinereous, with a few scattered short hairs. Coxae and femora black, cinereous, scales white, knees, tibiae and tarsi reddish, bristles of hind femora and setulae of posterior tibiae minute, rest of legs unarmed, posterior side of middle femora with distal patch of fine hairs. Wings hyaline, veins brownish, third vein with spur, underside of the discal cell with minute spur, first posterior cell at margin as wide as the base of the second submarginal cell, sections of the fifth vein proportioned 3 : 5; halteres yellow.

Female.—Head with white sheen, whole of front with pale yellowish tomentum and appressed minute hairs; face below, cheeks and mouth opening yellowish; tomentum of occiput yellowish. Abdomen wholly covered with whitish tomentum, the pile very short, caudal fimbria long and golden, closing the anal opening. Legs reddish. Sections of fifth vein 1 : 2, spur of third vein strong.

Holotype: Male, Wilcox, Arizona, September 14, 1935 (F. H. Parker). *Allotype:* Twenty-nine Palms, California, August 9, 1946, on Stinking Clover, *Wislizenia refracta* (P. H. Timberlake, in Citrus Experiment Station).

The female is similar to *E. pulvereus*, but can be differentiated by the face and cheeks yellow in ground color to the eyes, the difference in the anal orifice and the stronger spur of the third vein.

This species so closely resembles *Aphoebantus pellucidus* Coquillett that the two are undoubtedly related. The face of *pellucidus* is less prominent, the body is more hairy, the abdomen of the male quite pilose, the pygidium is much smaller and the ovipositor is shining. The principal difference lies in the structure of the proboscis, which in *pellucidus* terminates in a short fleshy haustellum.

Genus **Eucessia** Coquillett

Eucessia rubens Coquillett

Eucessia rubens, the genotype and by present restriction the only representative of the genus, is a beautiful fly, easily recognized by its reddish abdomen which is marked with a basal band of three vittae of white tomentum. Because of its close similarity to *Aphoebantus* the species has been included in the tabulation of that genus.

Professor Timberlake has taken *rubens* on flowers of *Euphorbia albomarginata* at Riverside, California, May 22, 1925.

Genus **Aphoebantus** Loew[4]

KEY TO THE SPECIES OF APHOEBANTUS

1. Scutellum bilobed and sulcate, the groove marked with a streak of tomentum. 2
   - Scutellum rounded on hind margin, at most slightly emarginate, the apex sometimes with a patch of denser tomentum. 4
2. Abdomen with some black scales arranged in paired spots; hind femora with spinous bristles; halteres brownish. 3
   Abdomen with alternate bands of yellow and white tomentum; notum of female with golden scales; bristles of hind femora weak; halteres yellowish; pile of front and face of male silvery white, of female frontal pile black and short; pygidium dorsally with loose long reddish hairs. . . . . **bisulcus**
3. Face vertical, with orange pile and no tomentum, front of female with golden pile becoming black above and no tomentum; black spots of abdomen well defined in the midst of dense yellow tomentum. . . . **maculatus**
   Face retreating, with white pile and tomentum, front of male with white pile and tomentum, of female with mostly black pile and whitish tomentum; black marks of abdomen indefinite. . . . . **gluteatus**

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[4]I have not recovered the following species and therefore have nothing to remark about them, but have included all in the table from data given in their descriptions: *argentifrons* Cole (1923), *capax* Coquillett, *carbonarius* Osten Sacken, *cervinus* Loew, *concinnus* Coquillett, *fumidus* Coquillett, *pavidus* Coquillett.

4. Abdomen with some black scales (light-colored greasy scales turn black and must be disregarded.).. 5
   Abdomen wholly without black scales, sometimes dark brown scales present..29
5. Scutellum with hind margin shining and devoid of tomentum (except possible apical patch)... 6
   Scutellum evenly dull or pollinose or tomentose over whole disk...........15
6. Bands of black scales of abdomen interrupted in middle; hind femora with bristles but no long hairs below............................... 7
   Bands of black scales not interrupted on median line; knob of halteres usually yellow.. 8
7. Pile of front mostly black; halteres brown; scutellum with apical spot or median line of tomentum; abdomen with long and usually black hairs on rear of segments; ventral piece of pygidium lobed above. (If distal part of third antennal joint is not styliform, see *arenicola*, couplet 40. If frontal pile is black but knob of halteres mostly ivory, abdomen devoid of long hairs and scutellum without apical concentration of scales, see *mixtus*, couplet 27.).....................................**interruptus**
   Pile of front whitish; halteres light yellow; scutellum all shining behind; abdomen without black hairs; ventral piece of pygidium straight above..**vulpecula**
8. Black scales forming a broad median stripe or series of spots, sometimes reduced to indefinite basal spots on second and third segments; hind femora with long fine hairs beneath (basal in *ursula*).................. 9
   Black scales forming wide bands alternating with whitish tomentum on the incisures; third vein without spur. (If posterior femora have both long hairs and strong bristles and third vein has a short spur, see *desertus*, couplet 28.)..13
9. Hind tibiae and tarsi yellow; abdominal spots quadrate and distinct, located on segments 2 to 6; front with white scales and pile; hind femora without bristles; halteres yellow; costal setulae yellow at base of wing; harpagones spatulate..10
   Legs blackish; abdominal black spots not quadrate; costal setulae black; harpagones ending in a deflexed hook....................................11
10. Seventh tergite laterally fringed with long white hairs; black spots of abdomen occupying half of the upper side of the segments; mesonotum and scutellum appearing blackish because of the open tomentum...**inversus**
    Seventh segment of abdomen hairy but not fringed; black spots small, occupying about one-sixth of upper surface of the segments; mesonotum and scutellum appearing gray because of the close tomentum....**catenarius**
11. Hind femora without bristles but with long hairs below; pile of front of both sexes blackish; scutellum without apical spot; seventh tergite with dorsal fringe of white hairs; harpagones with basal digitus, posterior edge of ventral sheath notched on each side; third vein without spur. (See couplet 14 for female.)....................................**scalaris,** male
    Hind femora usually with bristles and hairs; pile of front of male white; harpagones without appendage, ventral sheath not notched behind; third vein with spur; styliform part of third antennal joint twice as long as basal bulb...12
12. Pile of face whitish to brown; scutellar margin without scales; pygidium massive, polished black, not tomentose but pilose. (*catulus* Coquillett), **desertus** male
    Pile of face white; scutellum with apical tomentose spot; pygidium small, tomentose but not pilose, the apex luteous, valves glaucous.........**ursula**
13. Pile of front mostly yellowish; hind femora typically with a few setiform hairs below; halteres pale yellow; tibiae and tarsi largely reddish; basal costal setulae mostly yellow. (See couplet 23.)..............**marginatus**
    Pile of front mostly blackish; hind femora with about eight long hairs and no bristles; legs blackish; costal setulae black to root of wing..............14
14. Pile of face whitish; halteres brownish; ground-color of body subshining, incisures of abdomen white-tomentose; hairs of femora white; length 7 mm. (See couplet 11 for male.).....................**scalaris,** female
    Pile of face black; halteres yellow; body polished blue-black, tomentum very sparse; hairs of femora, etc., black; length 5 mm..............**denudatus**

15. Thorax with two vittae of white scales, abdomen with a median white stripe; eyes of male separated; front with white pile and dense tomentum. (See couplet 48.)..**vittatus**

    Thorax and abdomen without definite vittae of white scales..............16

16. Black scales of abdomen forming a median series of spots; halteres yellow...17

    Black scales forming broader cross-bands................................18

17. Pile of front and face white; hind femora with only sparse hairs below; pile of abdomen sparse, black spots located on segments 3 to 7. (If harpagones are thin and spatulate and abdomen is pilose, see couplet 10. If hind femora have many bristles and hairs and abdomen is abundantly pilose, see *eremicola*, couplet 52, if pygidium is as long as two preceding segments; or *desertus*, couplet 28, if pygidium equals three segments.)..**argentifrons**

    Pile of front and face black; hind femora with three bristles and no long hairs; pile of abdomen abundant, black spots located on segments 2 to 6...**scriptus**

18. Knob of halteres at least in part brown or black; hind femora with bristles; pile of front more or less black; face without tomentum................19

    Knob of halteres altogether yellow......................................22

19. Pile of face white; scutellar bristles pale............................20

    Pile of face at least in part black; some or all scutellar bristles black........21

20. Styliform process of third antennal joint about twice as long as bulb; black bands extending across abdomen, white bands of hind margins narrow in female, absent or very narrow in male; hind femora with some long hairs beneath; male with eyes contiguous or nearly so almost third-way to antennae, abdomen with abundant long white pile, forceps concealed...**mus**

    Styliform process about one and one-fourth times as long as bulb; black bands of abdomen laterally flanked by whitish scales; broader whitish bands on hind margins; hind femora with very few or no long hairs; (male not known). (Compare couplet 27.)....................**brevistylus**

21. Eyes of male barely touching; abdomen wholly with abundant long white pile, pygidium small...**mus**, var. **barbatus**

    Eyes of male contiguous halfway to antennae; abdomen with loose black hair, pygidium swollen and with black hairs above.............**halteratus**

22. Pile of face pale, face usually without tomentum (a few yellowish scales in female of *hirsutus* and white in *marginatus*); third vein without spur as far as known..23

    Pile of face black, or black and reddish; styliform process of last antennal joint one and one-half times as long as bulb; basal costal setulae black...28

23. Pile of front mostly or wholly pale; abdomen of female with alternating contrasting black and white bands; hind femora usually without bristles but with a few setiform hairs, the apical ones may be bristle-like; styliform process of third antennal joint about as long as bulb. (See couplet 13.)...**marginatus**

    Pile of front wholly or partly black....................................24

24. Styliform process of third antennal joint about twice as long as bulb; hind femora with some long white hairs below............................25

    Styliform process about as long as bulb; hind femora with two to four bristles but no long hairs...26

25. Black bands of female abdomen scarcely wider than yellowish ones, male abdomen elliptical, the bands indistinct, pile long dense and white, forceps not projecting; hind femora with bristles, male with white-pilose femora and anterior tibiae with fringe of white hairs behind; base of costa with yellow setulae. (If apex of scutellum has a dense patch of scales and first band of black tomentum is notched behind by intrusion of white scales, see *ursula*, couplet 12.)................................**hirsutus**

    Black bands much wider than the marginal white fringes; forceps projecting; hind femora without bristles..........................**carbonarius**

26. Pile of face golden, pile of front black and red..............**capax**, female

    Pile of face white, pile of front black; base of costa with black setulae....27

27. Mesonotum with some black hairs, bristles of scutellum reddish; black scales of abdomen interrupted in middle of segments two and three and absent from segment six..**mixtus**

Mesonotal pile and bristles pale yellow; black fasciae continuous, sixth
  segment with black scales. (If bristles of scutellum and rear of thorax
  are strong and black, see *parkeri*, couplet 60.).................**brevistylus**
28. Hind femora with bristles but no long hairs; face without tomentum; third
  vein without spur......................................**scriptus,** female
  Hind femora with long hairs and bristles below; face with sparse yellow
  tomentum; third vein with spur..............................**desertus**
29. Ground color of abdomen yellowish or reddish; femora mostly or wholly
  yellow, hind femora without long hairs; scales of body mostly yellow.....30
  Ground color of abdomen black; femora almost always black except knees...33
30. Front with many orange scales; antennae all luteous; scales of abdomen
  almost unicolorous orange; eyes of male almost contiguous; ventral
  piece of pygidium compressed, the upper apex prolonged; size 9 mm.
  sperryorum
  Front with but few or no scales; third antennal joint blackish; abdomen
  with some white scales; size smaller.................................31
31. Femora wholly yellow; abdomen without median brown spots in ground
  color; front without scales...32
  Front femora usually in part brown; abdominal segments with posterior
  fringe of white scales, usually a median row of brown dots in ground
  color; front with some yellow scales; face wholly pilose; size 3–5 mm.
  (See couplet 59 for male and dark form of female.)................**varius**
32. Second abdominal segment with wide fascia of white scales; third antennal
  joint with styliform apex half as long as bulbous base; scutellum opaque;
  trochanters with basal black spot; three-fourths of face pilose; size
  7 mm..**concinnus**
  Abdomen with basal band and dorsal and lateral vittae of white scales, the
  vittae sometimes reduced to rows of basal triangular spots; third antennal
  joint broadly oval, scarcely longer than wide; face with only oral pile, pile
  of front in two stripes; eyes of male quite widely separated; pygidium
  much dilated below; scutellum polished behind; size 4–5 mm...**Eucessia rubens**
33. Wings brown at base, sometimes faintly so, hairs on base of costa black....34
  Wings hyaline, the subcostal cell sometimes yellowish...................37
34. Scutellar margin bare and shining; pile of front of both sexes partly black;
  all tibiae and posterior femora with bristles, legs of female sometimes
  reddish; abdomen with black hairs, the tomentum white on basal half of
  segments and yellow beyond..................................**transitus**
  Scutellum opaque; abdomen without black hairs and without basal bands
  of white tomentum on segments......................................35
35. Scutellum without bristles though hairy; first segment of abdomen with
  band of white scales; dark part of wing almost confined to root and
  prefurca, third vein usually with stump; third antennal joint somewhat
  conical...**cyclops**
  Scutellum with yellow bristles; infumation of wings more extended........36
36. Femora reddish, hind femora with bristles and short hairs; styliform part
  of third antennal joint shorter than base; abdominal segments narrowly
  margined with white tomentum; second basal cell almost hyaline; eyes
  of male touching...**fumidus**
  Femora black, without bristles but with long hairs below; styliform part of
  third antennal joint longer than base; tomentum of abdomen uniformly
  whitish or yellowish; second basal cell usually almost all smoky; middle
  hairs of face sometimes blackish, especially of females; eyes of male usually
  somewhat separated. (*fucatus* Coquillett, male).................**fumosus**
37. Pile of face mostly or wholly black......................................38
  Pile of face whitish or yellow, sometimes fulvous.......................39
38. Scutellum subopaque; styliform part of third antennal joint one-half longer
  than base; front of male and frontal hairs black; hind femora without
  long hairs; abdomen of male with long white pile, pygidium small, apical
  corners of ventral plate extended back in a rounded or angulate lobe.
  (See couplet 59 for pale-bearded form.)...........................**tardus**
  Scutellum shining; styliform part of third antennal joint twice as long as
  base; front of female shining black and black-pilose, of male silvery and
  with white pile; bristles of body and legs weak, hind femora with long
  hairs; pygidium massive, one-third to one-half as long as rest of abdomen,
  the corners of ventral part not prolonged.........................**peodes**

39. Scutellum with hind margin shining, base and sometimes apical spot tomentose; notum with yellow to fulvous scales. (If scales are white and eyes of male slightly separated, see *separatus*, couplet 64.).............40
    Scutellum evenly pollinose, the tomentum spread over upper surface; attenuated part of third antennal joint two-thirds to one and two-thirds times as long as basal bulb..44

40. Styliform part of third antennal joint very slender, cylindrical and abruptly constricted from the bulbous base. (If abdomen has large paired marks of brown tomentum, see *vulpecula*, couplet 7.).........................41
    Third antennal joint rather conically tapering; pygidium without long hairs, the ventral plate lobed above, in profile hiding valves, caudal angles broadly rounded; third vein without spur; tip of scutellum with small spot of scales; ground color of thorax dull, postalar declivities cinereous; face nearly vertical, pile of face and front of male white, of female yellowish...**arenicola**

41. Hind femora with delicate hairs but no bristles beneath; third vein without spur; abdomen of female with fulvous tomentum, the incisures with contrasting bands of white scales...........................**altercinctus**
    Hind femora with bristles but no long hairs; third vein with spur; abdominal incisures not conspicuously white-tomentose.........................42

42. Incisures of abdomen with rows of erect black hairs, scales of body yellowish brown; bristles of scutellum and rear of thorax strong and black; pile of front of female black...43
    Abdomen with no black hairs, pygidium large, above caudally with many golden brown hairs; tip of scutellum with spot of scales, bristles reddish; notum subshining, scales of body mostly ochreous, postalar declivities shining; frontal pile of female reddish brown to blackish..........**borealis**

43. Halteres blackish; apex of scutellum with tomentose spot; tomentum in general yellowish, well-marked specimens with incisures and median line on abdomen narrowly white; ventral hairs at base of antennae white; first posterior cell greatly narrowed at apex; abdomen of male rather coarctate, pygidium truncately conical...................**conurus**
    Halteres pale yellowish; hind margin of scutellum denuded; tomentum of thorax and abdomen fulvous; hairs at base of antennae black. (If bristles of thorax and scutellum are pale yellow, base of antennae white-pilose and pygidium piceous, see *vulpecula*, couplet 7.)............**cervinus**

44. Rear of thorax, scutellum and femora without bristles...................45
    Thorax and scutellum with bristles....................................48

45. Abdomen without basal band of white tomentum, body rather uniformly coated with appressed hairs or scales; third vein without spur; face nearly vertical, oral rim yellow; third antennal joint rather elongate triangular. (If proboscis is pointed and third vein has spur, see *Epacmus tomentosus* and *pulvereus*.)..................................46
    First segment of abdomen with conspicuous band of white scales, the whole body subshining black without appressed covering; third vein usually with spur; face receding; third antennal joint conical with rather distinct styliform apex; legs black...47

46. Body farinaceous, densely covered with matted whitish or yellowish hairs; seventh segment of female abdomen polished black; tibiae yellowish; dorsal prongs of pygidium pruinose........................**pellucidus**
    Body covered with short appressed yellowish scales; apex of female abdomen not differentiated; legs black, or tibiae reddish at base; last ventral segment of male large and projecting downward....................**rattus**

47. Pygidium large, in rear view wider than deep, the upper valves completely cinereous, the basal hairs not reaching apex; basal costal fringe blackish. (Compare couplet 35.)...**cyclops**
    Pygidium small, in rear view deeper than wide, the upper valves polished on apical half, with the basal hairs reaching apex; basal costal fringe whitish, root of wing not infumated..........................**balteatus**

48. Disk of thorax bivittate with white scales, abdomen with median stripe of white scales; eyes of male separated; scutellar bristles black; front with dense tomentum and short procumbent pile. (Compare couplet 15.) **vittatus**
    Thorax and abdomen without definite vittae of white scales; scutellar bristles pale to reddish..49

49. Hind femora with some long hairs beneath...........................50
    Hind femora without long hairs but with bristles; styliform part of third antennal joint about equal to bulb....................................54
50. Front densely coated with scales and almost or wholly devoid of pile; hind femora with two small bristles and few long hairs; middle femora fringed with white hairs behind; styliform part of third antennal joint two-thirds as long as base; tomentum of abdomen yellow; third vein without spur; length 4–6 mm...51
    Front with variable tomentum, but its abundant pile suberect............52
51. Pygidium large; eyes of male contiguous; white tomentose fasciae at base of abdominal segments; front of female without pile, of male with sparse suberect pile..**pavidus**
    Pygidium minute; eyes of male separated the width of ocellar triangle; white tomentose fasciae located principally at apex of segments; front of male without pile...**obtectus**
52. Hind femora without bristles; styliform part of third antennal joint about equal to base; middle femora with no or with weak bristles beneath but with white hairs behind; third vein without spur......................53
    Hind femora with many bristles and hairs; middle femora with bristles below and some hairs behind; styliform part of third antennal joint much longer than bulb; third vein with spur; harpagones apically shining; length 10 mm..**eremicola**
53. Harpagones gray pollinose except a large lateral polished space; abdomen of male cylindrical; costal setulae and veins mostly blackish.........**marcidus**
    Pygidium very small, the dorsal parts concealed; abdomen of both sexes broadly depressed; all costal setulae and veins yellow...........**micropyga**
54. Pile of face and front deep golden yellow; abdomen with yellow and whitish tomentose fasciae and erect white hairs on incisures, sides rather pilose; eyes of male narrowly separated; face greatly retreating; styliform part of third antennal joint equal to base; pygidium very small, almost concealed; size 7–10 mm.................................**capax,** male
    Pile not golden, of face white, yellow, red, brown, or absent above; otherwise not completely conforming....................................55
55. Face strongly receding, pilose almost to antennae; eyes of male contiguous...56
    Face not receding, nearly vertical, with overhanging oral moustache, bare toward antennae; pygidium without tomentum.......................61
56. Pygidium half as long as rest of abdomen, strongly compressed and tomentose; anterior femora pilose behind; scales of front, notum, scutellum and abdomen deep yellow and abundant; first posterior cell almost closed, third vein with spur............................**abnormis**
    Pygidium much smaller, ventral piece not compressed; scales of front not dense..57
57. Bristles pale; abdomen without black hairs; third vein not appendiculate; apical corners of ventral piece of pygidium more or less prolonged backward...58
    Bristles of scutellum and rear of thorax strong and black; thorax and abdomen of male tomentose rather than pilose; abdomen of female with black erect hairs near incisures; ventral sheath of pygidium tomentose; first posterior cell much narrowed, third vein with spur, costa black-setulose to base...60
58. Pygidium widely gaping, harpagones largely joined at base resembling an eighth tergite, ventral piece deeply excised at apex; frontal scales abundant...**hians**
    Pygidium closed, harpagones entirely separated, ventral piece not excised; frontal scales sparse..59
59. Thorax and abdomen of male pilose; front of female black-pilose; pygidium wholly black, without tomentum; branch of third vein sinuous; size 5–9 mm..**tardus,** var.
    Pile sparse; hairs of front pale; ventral piece of pygidium with white tomentum, the upper part rufous; branch of third vein gently curved; size 3–5 mm......................................**varius,** dark form
60. Pygidium with only short pile, upper rear angles of ventral piece rectangular; abdomen of female with intermediate dark brown bands...........**parkeri**

Pygidial valves with long dark hairs, the upper rear angles of ventral piece acutely produced; abdomen of female with median row of brown spots..**mormon**

61. Outer part of third antennal joint distinctly styliform in most aspects; front and face without tomentum; upper part of front of female black, subshining, centrally bare, frontal pile of female brown; pygidium rather large, black, valves shining and deeply indented on the side; bristles of hind femora strong; eyes of male separated.....................**vasatus**

Third antennal joint rather elongate conical, the apex scarcely or not at all styliform; front nowhere shining black, its pile white................62

62. Eyes of male meeting about third-way to antennae; bristles of hind femora strong..63

Eyes of male separated by the width of an ocellus; bristles of hind femora weak...64

63. Pygidium strong, harpagones robust, two-thirds as wide as long and gray, upper part of ventral piece with backward directed yellow hairs and not inflexed; tomentum of thorax and abdomen mostly pale fulvous; mystax coarse and golden; third vein with spur, veins thickened and black at apex of subcostal cell..**timberlakei**

Pygidium small, bare, harpagones minute, piceous, upper part of ventral piece inflexed; tomentum of thorax and abdomen whitish; hairs of face delicate, white; third vein sinuous, no stigma...................**contiguous**

64. Front of both sexes devoid of tomentum; scales of abdomen whitish; scutellum when viewed from in back somewhat shining beneath, but the surface uniformly tomentose...................**contiguous,** var. **separatus**

Front densely covered with white scales; scales of abdomen pale yellow, but those of hind margins of segments white; scutellum altogether opaque...**leviculus**

Aphoebantus abnormis Coquillett
Figure 25

A male from Vallecitos, San Diego County, April 26, 1936, furnished by Commander C. M. Dammers, agrees with the general description but does not conform with Coquillett's wording of the structure of the enormous pygidium. The ventral piece is vastly larger than the upper valves, and is strongly compressed and keeled. Coquillett stated that the hypopygium is divided lengthwise into an upper and lower piece, the latter scarcely one-fourth as large as the upper. I interpret his description as applying to a gaping pygidium which might resemble the beak of a parrot, but he has reversed the upper and lower parts, for the jet-black white-bordered erect piece is caudal to the ventral keel and not attached to the upper harpagone. This paired structure is the homolog of the customary black villous knobs of other species. Mr. Dammer's specimen has a long erect arcuate filiform penis emerging from the apex of the ventral piece.

A female from Blythe, California, May 1, 1947, represents the other sex of this species, having the same shagginess of front and face, same coloration and venation. The tomentum is slightly paler than the male's. The posterior side of the anterior femora is rather hirsute. Apex of the first posterior cell greatly narrowed, being one-third the length of the posterior crossvein, branch of the third vein with strong spur.

Aphoebantus altercinctus, n. sp.

Female.—Length 5 mm. Vertex and middle of front shining black more than halfway to the antennae, rest of front becoming cinereous,

front about one-third as wide above as at antennae, the pile not abundant, white and almost confined to the cinereous area, almost no tomentum; face strongly receding, gray-white, the whitish pile present on all but a small infra-antennal space, no tomentum; occiput gray pruinose above and below, whiter along the middle where the white scales are denser; hairs at base of antennae short and white, base of third joint very short, onion-shaped, the abruptly slender styliform process twice as long as the base; proboscis very short and thick, palpi fuscous. Thorax gray, the tomentum, hairs and bristles pale yellow; scutellum with scattered tomentum on basal half, no apical spot; pleura heavily cinereous, the scales and pile white; postalar declivities glaucous. Abdomen with scattered short white hairs, but with dense tufts on the first segment, second and following segments covered with deep fulvous tomentum, all incisures banded with white scales, venter and inflexed edges of the segments white-tomentose, hind margins of the sternites yellowish in ground color, last sternite black and devoid of tomentum. Coxae and femora black, with white tomentum, the knees, tibiae and tarsi luteous, femora devoid of bristles, the hind pair with spaced white hairs below which are about as long as the diameter of the femur, hind metatarsus without spine. Anterior and basal veins luteous, others blackish, no black costal setulae at base of wing, first posterior cell scarcely narrowed apically, sections of fifth vein 2 : 3; halteres pale yellow, only the root a little darkened.

Holotype: Concho, Arizona, June 19, 1947 (J. L. Sperry).

The species name refers to the conspicuous alternate bands of fulvous and white tomentum.

Aphoebantus arenicola, n. sp.
Figure 48

Male.—Length 5 mm. Eyes contiguous for a distance equal to the space between the ocelli; front silvery, the pile pure white, parted down the middle and absent along the orbits, no tomentum; face silvery, bare above, white-pilose below, not tomentose, nearly vertical to the elongate mouth-opening, proboscis correspondingly long, palpi yellowish; basal antennal joints with white hairs, the third joint not abruptly styliform, twice as long as deep, the conical base merging with the apical half. Bristles of thorax and scutellum unusually strong, reddish brown. Abdominal scales mostly fulvous or pale yellow, hind margins of segments with a narrow fringe of white tomentum, slight indications of paired patches of brown scales, all hairs long and white; pygidium devoid of tomentum and long hairs, prominent, in profile the ventral sheath lobed above, concealing the dorsal prongs and rounding into the posterior edge, the upper half of the sheath and the apical half of the prongs reddish brown. Sections of the fifth vein proportioned 1 : 3; knob of halteres pale yellow.

Female.—Upper frontal pile black becoming yellowish below.

Holotype and *allotype:* Sierra Blanca, Texas, April 24, 1942. *Paratypes:* Three males, Globe, April 16, 1935, and May 5, 1936, and Florence Junction, Arizona, April 21, 1935, from F. H. Parker; one female, Lordsburg, New Mexico, May 1, 1942.

The species resembles *interruptus* but differs in having pale halteres,

white frontal hairs in the male, rather conical third joint of the antennae, and lacks the distinct patches of black scales on the tergites.

Aphoebantus balteatus, n. sp.
Figure 13

Male.—Eyes contiguous third-way to the antennae, front and most of occiput silvery white, face white, frontal hairs delicate, white and parted, orbits narrowly bare, a very few elongate white scales scattered among the pile: face strongly receding, with short white pile over all; sides of occiput with very few minute white scales; antennae black, basal hairs small, white, third joint conically tapering into the styliform portion; proboscis retracted, broadly haustellate, black, palpi black. Mesonotum closely white-pilose, without bristles and almost devoid of scales; scutellum uniformly rather dull, without bristles, its disk with delicate erect white hairs; postalar declivities glaucous and rugose; pleura thinly cinereous, the hairs and tomentum white. Abdomen rather shining, with abundant long white pile, almost devoid of scales except the prominent marginal fringe of the first segment; pygidium wholly black, ventral piece gently rounding to the lower apex and white-pilose like the rest of the abdomen. Legs wholly black, coxae without scales, femora with scattered white scales, middle femora white-pilose behind, hind femora with long white hairs below, tibial setulae small, hind metatarsi without apical bristle. Veins blackish, second submarginal cell sharply angulate at base and with a short spur, first posterior cell less than twice as wide at middle as at apex, sections of fifth vein proportioned 2 : 3: knob of halteres ivory, stalk darker.

Female.—Head almost wholly black, frontal and facial pile short and black. Pile of thorax and abdomen short, white, even the fimbria of the last segment. Hairs of femora much shorter than in the male. Sections of fifth vein 1 : 2.

Holotype and *allotype:* Baboquivari Mountains, Arizona, April 25, 1947. *Paratypes:* One male, Sabino Canyon, near Tucson, Arizona, April 27, 1948; a male and a female with the types.

This species is very close to *cyclops*, which it resembles in the conspicuous white fringe on the first segment of the abdomen and the absence of scutellar bristles. It is readily distinct in the much smaller pygidium, lack of dark color on root of the wing, the male abdomen definitely pilose, the female abdomen quite shining, the tomentum very sparse. The size range is from 5 to 8.5 mm.

Aphoebantus bisulcus Osten Sacken
Figure 37

Face receding, white-pruinose, covered with delicate white pile; front of male argenteous, with similar pile, front of female yellowish-gray, with black pile; styliform part of third antennal joint but little longer than the triangular base; palpi piceous. Mesonotum of male with whitish tomentum. Ventral piece of the pygidium projecting beyond the upper valves, the rear corners acute and reddish, the pair of caudal disks round, black and rimmed with yellow, upper valves glaucous and furnished with scattered white scales.

This species was described from a single female from Northern

Sonora. I collected a male in the Baboquivari Mountains, Southern Arizona, on April 27, 1947.

Aphoebantus borealis Cole
Figure 34
Proc. Cal. Acad. Sci., (4) 11 (15): 251, 1921.

Frank R. Cole described this species from a single male taken at Hood River, Oregon, June 25, 1917. On June 30 I visited the type locality with Dr. Cole and procured an additional male, which agrees completely with the description. It is a surprise to find in the collection of the Citrus Experiment Station that Professor Timberlake has collected the same species at Riverside, California. His specimens were taken at various times during May and June, some from flowers of *Lotus* and *Hugelia*.

The female has the front and occiput mostly subshining black, the frontal pile black above and brownish or fulvous below, the hairs of the face golden. Between the segments the abdomen is more distinctly fasciate with white scales than in the male.

Aphoebantus brevistylus Coquillett

I have several specimens which I am provisionally naming *brevistylus* although they do not agree fully with Coquillet's description of this species. Apparently, typical specimens of *brevistylus*, with continuous black bands on the abdomen, are quite different from *mixtus*, which has the black bands interrupted on segments two and three. The specimens I am calling *brevistylus* have broad black bands on the abdomen, but the incisures are fringed not with yellowish but with almost white scales, as in *mixtus*. Other characters of *brevistylus* shown by these specimens are the pale bristles of the notum and scutellum, absence of black mesonotal hairs, absence of yellowish tomentum between the black and white fasciae of the abdomen, white lateral scales, black scales on the sixth segment, styliform part of the third antennal joint somewhat longer than the bulb, and knob of halteres more or less brownish. They have a few long hairs under the basal part of the hind femora.

Three specimens from Miller Canyon in the Huachuca Mountains, Arizona, elevation 6500 feet, early May, taken with *cyclops*, but preferring the sandy and stony dry stream bed to the damper area frequented by *cyclops*; and one from the Alamo Canyon in the Organpipe Cactus National Monument, Arizona, April 23, 1947 (J. L. Sperry). The last specimen has the front at the vertex one-fourth as wide as at the antennae, in the others it is one-third as wide. Coquillett obtained his *brevistylus* from San Bernardino County, California. But since San Bernardino County is the largest and one of the most diversified counties in the United States the locality reference is hardly explicit if one wanted to visit the type locality for topotypic material.

Aphoebantus catenarius, n. sp.
Figure 39

Male.—Length 5 mm. Eyes contiguous about fourth-way to antennae, front and upper occiput silvery white, face and lower occiput white, frontal pile delicate, white and parted, with white tomentum

admixed, orbits bare; upper occiput with few white scales, lower scales dense; face strongly receding, covered with fine white pile and scattered white tomentum; base of antennae with white hairs, third joint with globular bulb and abruptly slender end of equal length, apical style distinct; proboscis short.   Disk of thorax subshining, with short whitish pubescence and appressed tomentum, collar a fringe of white hairs, longer white hairs about shoulders, bristles white; scutellum shining, with white scales on disk, the margin narrowly bare of scales, bristles whitish; postalar declivities glaucous; pleura cinereous, the tomentum and hairs white.   Abdomen not contracted, with rather long and abundant white pile, bushy on first segment, tomentum whitish, a band of white scales at apex of first segment, remaining incisures with very narrow bands of white tomentum, the median row of black spots on segments two to six conspicuous, the last smallest; pygidium small, twisted to the left, not pilose, ventral piece white-tomentose, the apical corners acute, valves spatulate, the tip not deflexed.   Coxae and femora white-tomentose, tibial spines yellow, hind metatarsus with terminal spine.   Veins mostly yellow, the black costal setulae not attaining root of wing, branch of third vein sinuous, apex of first posterior cell half the width at middle, sections of fifth vein 2 : 3.

Holotype: Gila Bend, Arizona, April 25, 1935 (F. H. Parker). *Catenarius*, Latin, like the links of a chain, referring to the series of black abdominal spots.

Aphoebantus contiguus, n. sp.
Figure 17

Male.—Length 4 to 5 mm.   Upper occiput, front and face argenteous, pile delicate and pure white, tomentum white and rather sparsely interspersed, facial pile spread over lower half, orbits bare; proboscis projecting the length of the upturned labellae, palpi yellowish; only about five minute hairs on basal joint of antennae, third joint about three times as long as deep.   Thorax dull gray, scales and dorsal hairs nearly white, anterior and lateral pile white, bristles long and pale yellow; scutellum similar to notum; postalar declivities black but slightly glaucous; pleura cinereous, the scales white.   Abdomen moderately pilose, the hairs all white, dorsal scales slightly tinged with yellow, basal, lateral and ventral scales white, incisures not differentiated, upper corners of ventral sheath bluntly obtuse.   Coxae and femora black, scales white, knees broadly and tibiae yellowish, tarsi apically brownish; a few hairs on posterior side of middle femora, bristles pale yellow, those of hind tibiae longer than diameter of the tibia, metatarsal bristle much shorter than tibial bristles.   First posterior cell only slightly tapering beyond middle, costa without black setulae, sections of fifth vein 1 : 4; halteres pale yellow, almost ivory.

Two specimens, Lynndyl, Utah, August 2, 1918 (George E. King)·

Aphoebantus contiguus var. separatus, nov.
Figure 19

Male.—Length 4 mm.   Very much like *contiguus,* differing in that the eyes are separated, the front and face lack all tomentum, the proboscis does not project, the scutellum is shining when viewed from the rear, and the bristles of the femora are weak.

Type and *allotype:* Wellton, Arizona, April 6, 1935. *Paratypes:* One male taken with the types; two females, Palm Springs, California, March 24, 1935, have the tibiae nearly black and one of them has about five white scales mingled with the pile over each antenna; a female collected by P. H. Timberlake five miles south of Coachella, California, March 7, 1936, on *Heliotropium*, is at the Citrus Experiment Station.

Aphoebantus conurus Osten Sacken
Figure 29

Face strongly retreating; a few middle hairs of front of male dark. Apex of scutellum with a spot of whitish scales, bristles of scutellum and thorax strong and black or dark brown. Abdomen above with dense appressed brownish tomentum, the hind margins of the segments narrowly fringed with white scales, venter uniformly whitish-tomentose. Upper valves of the pygidium rather small and narrow, provided with black hairs and whitish scales, the tips deflected and reddish, basal median triangle small and covered with whitish tomentum, ventral piece obliquely ascending to give a conical appearance to the pygidium. Third vein with long stump.

Eleven males and twenty females: San Bernardino Mountains, Borrego Desert, Mojave Desert near Phelan, Verdemont near San Bernardino, all in California; Huachuca Mountains, Pinal Mountains and Globe, Arizona (F. H. Parker). Two additional males from Borrego Desert (J. L. Sperry) and Morongo Valley, California, lack the distinctive black hairs of the abdomen. The collection of the Citrus Experiment Station also contains numerous specimens from Prescott, Arizona; Riverside, Hesperia and Berkeley Hills, California. The species is common from April to June, but some of the specimens from the Arizona mountains were caught in September.

This species is easily recognized by the greatly narrowed apical cell and the erect black hairs along the posterior part of the abdominal segments.

Aphoebantus cyclops Osten Sacken
Figure 12

This species was described from Northern Sonora, Mexico. Well-marked specimens have five stripes of white tomentum on the mesonotum. Front of male white pruinose, of female blackish; front and face of male with white tomentum and pile, of female with yellowish scales and pile; first segment of the abdomen with a conspicuous white fringe, the other segments with loose whitish tomentum and erect hairs, the tomentum of the female more yellowish than that of the male and the hairs very short.

Numerous specimens of this species were observed as they cavorted at the water intake in Miller Canyon, Huachuca Mountains, Arizona, elevation 6500 ft., during the first week of May, 1948. This locality is close to the Sonoran boundary. Several dozen specimens were collected and mounted though many more could have been taken for the insects were congregated in a small space near the end of the dam. The flies, unlike most Bombyliidae, were reluctant to arise in the insect net when it was placed over them.

Aphoebantus denudatus, n. sp.

Female.—Length 6 mm. A shining black, nearly bare species with a dark bluish reflection. Front half as wide above as at antennae, the hairs nearly erect and all black, face somewhat receding, its pile black; occiput blue-black, a few white scales on the sides, upper part with erect black hairs; styliform process of third antennal joint slender, cylindrical, a little longer than the bulb. Mesonotum with erect black hairs, on the sides with shorter reclinate white hairs which grade into fine tomentum over the wings, bristles long, hair-like and black; pleura shining, almost bare of scales and hairs, the upper mesopleura with some white pile. Some black scales across the upper side of the abdomen, the posterior fourth of the segments with loose white scales; white pile of first segment not as dense as usual, dorsum with scattered erect short black hairs, more evident to the rear, underside of abdomen shining, devoid of tomentum but with scattered fine white hairs. Coxae with almost no scales, the sparse hairs white, legs including the knees black, femora with whitish scales, all hairs and bristles black, the hairs under the hind femora about twice as long as the diameter of the femur. Veins blackish, first posterior cell but little tapering, sections of fifth vein 1 : 2; stalks of halteres light brown.

Holotype: Globe, Arizona, March 25, 1938 (F. H. Parker).

Aphoebantus desertus Coquillett
Figure 11

Synonym: *catulus* Coquillett.

Only females of *desertus* are known and only males of *catulus*. Although casually the two do not look much alike, they agree in essential characters. Bulb of third antennal joint about half as long as the styliform part; posterior femora with bristles, front and hind femora with long hairs below; scutellum shining but mostly covered with scales; third vein with short spur.

Male.—Eyes contiguous one-fifth the distance to the antennae, front and upper occiput silvery, frontal pile white, pile of face variable, usually dark. Tomentum and pile of body white and abundant, the median black spots of the abdomen not very distinct; abdominal pile long, pygidium massive, bare of scales but long-pilose.

Female.—Front and occiput black, front above half as wide as at antennae, pile of front and face black or dark brown, tomentum yellow. Tomentum of body yellowish, less abundant than in male, hairs shorter and yellow, the black scales of abdomen forming broad bands on about the anterior half of the segments, the posterior half and anterior corners have whitish-yellow scales.

Probably Coquillett's specimens of *desertus* came from the Borrego Desert or near by. I have taken it at Palm Canyon in this desert, April 1, 1946, and John L. Sperry has found it in the San Felipe Valley, April 27, 1946. I have collected it also in the Morongo Valley, California, April 19, 1944; Wellton, Arizona, April 8, 1935, and the Organpipe Cactus National Monument in Southern Arizona, April 14, 1948. The collection of the Citrus Experiment Station adds the following California records: Riverside, April 5, 1925, on flowers of *Gilia, Phycelia* and *Cryptantha* (P. H. Timberlake); Providence Mountains, April 10, on

Amphiacris (C. M. Dammers); near Adelanto, May 3 (T. D. A. Cockerell).

For the males, which would classify as *catulus*, I have taken some with the females at each of my previous localities, and also at Desert Hot Springs, California, April 4, 1945. John Sperry has furnished two specimens from the San Bernardino Mountains, near the headwaters of the Santa Ana River, June 1, 1947; and Professor Timberlake adds a male from Perris, California, April 18, 1937.

J. S. Hyslop has determined as this species (Proc. Ent. Soc. Wash., 1912, p. 101) a fly he reared from a pupa found in pine-needle mold on the summit of Moscow Mountain, Idaho.

Aphoebantus eremicola, n. sp.

Figure 15

Male.—Length 11 mm. Eyes with only a linear separation in front of the ocelli, upper occiput and front argenteous, frontal pile delicate and white with a few white scales admixed, covering the front except the bare orbits; face strongly receding, cinereous white, white-pilose except between the antennae, with scattered white scales; occiput cinereous beyond the glistening upper part, the white scales not dense; antennae black, hairs at base white and evident, third joint with piriform base, tapering into the rather slender compressed styliform part; proboscis short and thick, palpi fuscous. Thorax gray, abundantly coated with white scales and pile, dense along the sides, bristles whitish; scutellum similar to the notum; pleura black, the tomentum and pile white; postalar declivities dull black. Abdomen closely and uniformly white-tomentose, pile long, abundant and white; pygidium globose, without tomentum, harpagones short and broad, cinereous and hairy except the shining apex, ventral sheath short, shining, hairy, the corners rectangular, caudal disks almost triangular, covered with upturned black setulae. Coxae black, with very few scales, femora black except the knees narrowly yellowish, scales rather sparse and white, front and hind femora pilose beneath, middle femora with some distally directed hairs on apical half of posterior side, posterior femora spinose beneath, hind tibiae and tarsi dark fuscous, the others black, terminal spine of hind metatarsus undeveloped. Costal and basal veins light brown, the others blackish, root of wing black, basal costal setulae deep golden, apex of first posterior cell one-third the width at middle, spur of third vein strong; halteres with ivory knob and pale brownish stalk.

Female.—Front half as wide at top as at antennae, subshining black, the pile blackish and extending to the eyes; face dark gray, covered with yellow to fulvous pile, tomentum of head sparse, yellow; occiput almost black; palpi black. Thorax with yellow tomentum, pile and bristles, scutellum wholly opaque, pleura black with slight gray tone, without tomentum, the pile whitish. Abdomen depressed, subshining black, the tomentum yellowish, pile less noticeable than on the male, whitish, underside with white tomentum and hairs.

Holotype: Desert Hot Springs, California, April 4, 1945. *Allotype:* Palm Springs, California, April 4, 1935. *Paratypes:* Male, Ocotillo, in the Borrego Desert, California, March 6, 1947 (J. L. Sperry); male, Wellton, Arizona, April 6, 1935; female, Organpipe Cactus National

Monument, Arizona, April 14, 1948; female, Florence Junction, Arizona, April 18, 1935 (F. H. Parker).

The specimen from Ocotillo has slight indications of mid-dorsal dark tomentum on segments two to four. It is heavily covered with white scales which on the mesonotum are concentrated to suggest five vittae.

Aphoebantus fumosus Coquillett
Figure 18

Coquillett described the female in 1892 as *fumosus*, and in 1894 he described the male as *fucatus*. On April 24, 1946, near Palmdale, California, and again at the same place March 27, 1947, I took many specimens of both sexes consorting at the roadside, some in coitu. The females have black frontal pile, the males white, a frequent sex attribute, which difference in color led Coquillett to think he had two species. Additional localities show an extended distribution. The dates range from the middle of March in the lower desert to early May in the uplands. CALIFORNIA: Lovejoy in the Mojave Desert, Morongo Valley, Joshua Tree National Monument, Perris, Verdemont, Oak Grove, Lake Cuyamaca. P. H. Timberlake has collected the species at Riverside on *Cryptantha*, and at Edom near Palm Springs. M. C. VanDuzee has taken it at San Diego. ARIZONA: Florence Junction, Globe and San Carlos (all F. H. Parker).

Aphoebantus gluteatus, n. sp.
Figure 36

Male.—Length 8 mm. Eyes briefly touching in front of the ocelli, upper front cinereous becoming white-pruinose, the tomentum and abundant pile white, parted down the middle; face white, receding, completely white-pilose; occiput white-cinereous, tomentum white; hairs of base of antennae white, third joint with small globular bulb, the abruptly slender styliform part about twice as long as the bulb; proboscis very short, broadly haustellate, palpi fuscous. Notum dull gray, the straggly tomentum whitish, bristles and hairs of disk reddish; lobes of scutellum polished black, bristles reddish, tomentum yellow and dense along the suture; postalar declivities glaucous black; pleura cinereous. Abdomen with long loose white hairs becoming brownish posteriorly, pile of first segment bushy; the rather indefinite spots of black scales bounded by yellow, incisures and a somewhat vague median vitta marked by white scales; the deflexed sides of the abdomen and the ventral incisures reddish yellow in ground color, tomentum white; pygidium blunt, upper valves short, with scattered white scales and rather long light-brown hairs, ventral piece largely reddish, furnished with white scales and long yellowish hairs, the corners forming an angle of eighty degrees and extending beyond the tip of the valves, the pair of black caudal disks oval and covered with microscopic upward-directed setulae. Legs openly white-tomentose, becoming luteous toward the knees, tibiae reddish, tarsi brown, the spinuous bristles of the tibiae and posterior femora strong, black on the femora and hind tibiae and red on the anterior tibiae, hind metatarsus without long bristle. Veins blackish, branch of third vein with a short spur, apex of the first posterior cell nearly as wide as the length of the posterior crossvein, sections of fifth vein 1 : 2; knob of halteres brown, the stalk luteous.

Female.—Front mostly blackish, face cinereous.   Hairs of abdomen
short, posteriorly black, apex of abdomen with setiform black hairs
projecting beyond the fimbria.

Holotype and *allotype:* Globe, Arizona, April 7, 1936. *Paratypes:*
Twenty-seven males and ten females, also from Globe, and one female
from near-by San Carlos, Arizona, all collected by F. H. Parker. One
female is oversize, measuring eleven millimeteres.   The species name
derives from the Greek *gloutôs*, the buttocks, suggested by the strongly
bilobed scutellum.

Aphoebantus halteratus, n. sp.
Figure 41

Male.—Length 4.5 mm.   Entirely black except the front legs slightly
brownish. Eyes contiguous halfway to the antennae, front quite black-
ish, face and occiput slightly cinereous, hairs of the front and face all
black, a few scattered white scales, hairs of the occiput short and black
but a ring of white hairs around neck, post-orbits with a row of white
scales, face strongly retreating, proboscis not projecting; base of the
antennae with a few black hairs, third antennal joint abruptly attenu-
ated, the styliform portion one and one-half times as long as the bulbous
base, style distinct, thin, nearly as long as the basal bulb. Thorax
opaque, lightly cinereous, its dorsal hairs rather sparse, black, but white
on the anterior margin, all bristles black, scattered white tomentum on
notum, scutellum and pleura, pleural and coxal hairs white, scutellum
concolorous with notum, with eight marginal bristles. Abdomen densely
coated with black scales beyond the first segment, but the sides, venter,
and narrow hind margins with white scales, dorsal hairs sparse and black,
lateral hairs white; pygidium rather sturdy, not shining, the dorsal
valves furnished with long stiff black hairs and some scattered white
scales, a basal triangle between the valves, the prominent ventral cradle
with white scales and a few small black hairs. Legs white-tomentose,
the front femora with a ventral row of eight long white hairs, middle
femora with some white hairs along the distal half, hind femora without
hairs but with a few small black bristles and a longer preapical pair; all
tibiae with moderate setae. Wings hyaline, veins black to the base,
third vein not appendiculate, anterior crossvein just before middle of
discal cell.   Halteres black, the middle of the stalk dark piceous,
calypteres and fine fringe white.

Holotype: Taken in the Mojave desert about four miles southwest of
Adelanto, California, May 23, 1945.

Allotype: A female taken by P. H. Timberlake (Citrus Experiment
Station) at Riverside, California, July 23, 1938, differs only in the
customary wide front and the conical end of the abdomen.

Aphoebantus hians, n. sp.
Figure 43

Male.—Length 5 mm. Eyes contiguous for two-fifths the distance to
the antennae; front white-pruinose, orbits narrowly glistening and bare,
frontal scales white, impacted in the upper angle, white pile intermixed;
face strongly receding, white-pollinose, almost uniformly covered with
white pile and with scattered white scales; upper occiput argenteous,

remainder cinereous-white, the scales white; the abruptly styliform end of the third antennal joint as long as the basal bulb; proboscis short, fleshy, palpi black.   Thorax and scutellum only slightly gray, uniformly speckled with small whitish scales, pile delicate and white, bristles pale; pleura cinereous, the hairs and scales white; postalar declivities concolorous with notum.   Abdomen slender (perhaps collapsed on drying so that the sternites are not visible), pile as long as each segment, delicate beyond the first segment, tomentum pale yellow, rather openly distributed but somewhat aggregated across the front edge of the segments; pygidium strongly gaping, devoid of scales, the hairs of the ventral piece sparse, long and delicate, harpagones joined at base, ending in a curious brown-crested uncus, edge of the central piece provided with a thin broad shelf which flexes outward at apex to form a spectacular brown-fringed lamella.   Femora piceous, scales white, rest of legs testaceous, hind femora with two inferior bristles, whole of posterior side of middle femora with white cilia, tibial bristles yellow, the terminal bristle of hind metatarsus as long as diameter of the joint.   Veins and costal setulae yellowish, no spurs, first posterior cell at apex half as wide as at middle, sections of fifth vein 1 : 2.5; halteres light yellow.

Holotype and *paratype:* Patagonia, Arizona, May 9, 1938 (F. H. Parker).   *Hians*, Latin, gaping wide open, referring to the exploded pygidium.

Alhoebantus hirsutus Coquillett

Eyes of the male contiguous or narrowly separated in front of the ocelli; front and face with scattered white tomentum, pile of front white above the antennae and black elsewhere, pile of face and on base of the antennae white.   Bristles of thorax and scutellum white; abdomen of male without white tomentose crossbands; bristles of legs whitish.   Root of wing luteous, base of costa with many white hairs.

The species was described from two males and two females from California.   I have a male determined by Coquillett from Los Angeles County.   Its eyes are contiguous in front of the ocelli.   See remarks under *mus* for further notes.

A female from Cedar City, Utah, received from H. Hagan, may belong here.   The abdomen has no yellow tomentum and the white marginal bands consist of elongate scales, ranging into hairs on the sides.   Coquillett stated that the abdomen of the·female is yellow-tomentose, with the bands of black scales indistinct and scarcely wider than those of white tomentum.

Aphoebantus interruptus Coquillett
Figure 47

Three males and three females belong here, coming from different localities in California: Keen Camp on Mount San Jacinto, June 7, 1942; Arrowhead Springs May 24, 1935, and Eastern Barton Flat, June 25, 1946, in the San Bernardino Mountains; Oak Grove at the base of Mount Palomar, May 9, 1945; Morongo Inn, May 10, 1935, and Borrego, May (the last collected by Noel Crickmer).   They agree well with the description, though two of the specimens show some blackish hairs in the middle of the beard.   The collection of the Citrus Experiment Station also contains a series of specimens, taken by P. H. Timber-

lake at Riverside, April to July, some on flowers of *Euphorbia albo-marginata* and of the introduced pepper tree.   F. H. Parker has furnished a specimen from Roosevelt Lake, Arizona, May 2, 1937.

Much of the scutellum is bare and polished; bristles of scutellum and rear of thorax black; face scarcely receding; styliform part of third antennal joint distinct from and somewhat longer than the bulbous base; black setulae of costa extending to base of wing.   Many of the specimens have long erect black hairs toward the hind margins of the abdominal segments.   The species is related to *arenicola*, having the same type of pygidium.

Aphoebantus inversus, n. sp.
Figure 40

Male.—Length 6.5 mm.   Eyes contiguous third-way to the antennae, upper occiput and front argenteous, orbits bare, frontal pile parted, whitish, with scattered white tomentum; face greatly retreating, white-dusted, white-pilose over all; occipital tomentum white; basal joints of antennae cinereous, the hairs small and white, bulb of third joint shorter than deep, abruptly tapering to the cylindrical styliform process which is slightly longer than the bulb; proboscis short, fleshy, palpi yellowish.   Mesonotum subshining black, the white scales discrete, slightly more congregated over base of the wings but not dense, discal pubescence white, all bristles whitish; scutellum more shining than notum, with open scales except narrowly along the hind margin; pleura cinereous, scales and hairs white; postalar declivities slightly glaucous. Abdomen with long and rather abundant white pile, denser laterally on first segment as usual, hind margins of tergites white-tomentose forming a distinct band on first segment and narrowly on the others and with a mid-dorsal knot of white tomentum on segments two to five, the black scales forming dense quadrate spots about twice as wide as long, sides of tergites white-tomentose, most dense on the anterior part of the second segment as well as on the venter; pygidium inverted, the sheath bearing white scales and the horizontal edges with long erect white hairs, the corners acutely rounded, harpagones bare, thin, the apical part blade-like and projecting straight backwards, caudal disks rounded triangular and blackish.   Legs brownish, coxae, femora and posterior tibiae closely white-tomentose, hind femora with hairs but no bristles below, tibial spines small and yellowish.   Veins yellowish, first posterior cell nearly half as wide at apex as at middle, fifth vein segments 1 : 2; halteres yellow.

Holotype: Belevue, Utah, June 23, 1919, received from Professor H. Hagan.   The abdominal pattern, peculiar pygidium and lateral fringe of long curved hairs on the last segment are distinctive.   *Inversus*, Latin, upside down, referring to the greatly twisted pygidium.

Aphoebantus leviculus Coquillett
Figure 20

This species was originally described by comparison with *catulus*, with which it has little relationship, because *catulus*, i. e., the male of *desertus*, has black scales on the abdomen, an elongate styliform end to the third antennal joint, greatly retreating face, shining scutellum and long hairs

on the femora.   Because the description of *leviculus* is brief several species before me conform, and the one to which I have assigned the name may not be Coquillett's species.

Third antennal joint gradually tapering, three times as long as deep, the tip blunt; face with scattered white scales, the beard not confined to the oral margin, front with short pubescence rather than pile, the scales and hairs descending between the antennae and eyes; pygidium short, devoid of tomentum and pile, ventral sheath with the outer corners undeveloped, obtusely blunt; veins light yellow, costal setulae all pale, sections of fifth vein 1 : 2.5; halteres ivory white.

CALIFORNIA: Palm Springs, April 23, 1933, on sand; Mecca, April 13, 1934, on *Heliotropium* (both by P. H. Timberlake).   ARIZONA: Buckeye, March 29, 1934, on *Heliotropium* (Timberlake); Palo Verde, April 22, 1935, (F. H. Parker).   SONORA, MEXICO: 83 kilometers south of Border on highway from Organpipe Cactus Monument, April 24, 1947, on sand dune.

Aphoebantus maculatus, n. sp.

Female.—Length 7.5 mm.   Head mostly satiny white, a little darker at the ocelli, upper occiput swollen and deeply grooved; face bare above, the beard decumbent and extending across the oral margin, tomentum of occiput white; a few white hairs at base of the antennae, third joint divided equally between the bulbous base and attenuated apex; proboscis not projecting, haustellate, palpi light brown.   Mesonotum dull gray, the tomentum yellow, becoming white on the sides, anterior pile yellow, dorsal hairs light brown, anterior bristles yellow, posterior reddish; postalar declivities glaucous; scutellum densely coated with yellow scales except the two polished posterior umbos, bristles reddish; pleura cinereous, pile and tomentum white.   Abdomen above with dense coating of yellowish scales, second to sixth segments with paired crescentic black-tomentose marks on the front margins, first segment with bushy yellow pile, abdomen elsewhere with white or whitish hairs, the deflexed sides and venter white-tomentose.   Femora with yellow scales on front surface, posteriorly white-scaled, knees, tibiae and tarsi luteous, bristles of posterior tibiae strong, reddish.   Veins light brown, base of submarginal cell angulate, first posterior cell half as wide at apex as at middle, sections of fifth vein about 1 : 4.

Holotype: Globe, Arizona, April 16, 1935 (F. H. Parker).

Aphoebantus marcidus Coquillett
Figure 28

This species exhibits considerable variation   Specimens from the Borrego Desert have the costal setulae all yellow and a small yellow epaulette at base of the costa, the body wholly black, with tomentum, pile and bristles whitish.   Specimens from Picacho have the inflexed sides of the abdomen reddish, the tomentum, pile and bristles slightly yellow, and no costal epaulette.   Males from the Organpipe park have pale ochraceous scales on the abdomen.   Specimens from Globe have the tomentum strongly ochraceous and the frontal pile of the female black, no epaulette, the black setulae of the costa continuing almost to root of the wing.   The specimens from Wyoming are distinctly smaller

than the others; they are badly denuded.   All agree in having the first posterior cell rather widely open.   The apical angles of the ventral piece of the pygidium are rectangular.   Pilosity of body and legs varies in amount.   The following localities are represented.

CALIFORNIA: Borrego, March 2 (J. L. Sperry); Ocotillo, March 6 (J. L. Sperry); Upper Santa Ana River, June 9.   ARIZONA: Wellton, April 6; Picacho Peak, April 8; Organpipe Cactus National Monument, April 12; Globe, April 21–May 1 (F. H. Parker).   UTAH: Leamington, July 23 (received from H. Hagan).   WYOMING: North of Lusk, July (from University of Kansas).

Aphoebantus marginatus Cole

1923. Proc. Cal. Acad. Sci., (4) 12 (25): 310.

This species was based on a female from Tiburon Island, Gulf of Lower California.   I have six females from different localities whose variations can come within the species range.   All have the scutellum more or less shining, but the amount of surface tomentum varies from complete coverage to a restriction of the scales to the base and lateral angles.   The intermediate yellow scales, between the broad black bands and the conspicuous white-tomentose hind margins, may not be developed.   The "fine bristles" of the underside of the hind femora mentioned by Cole vary in stiffness.   Only females of this species are known.

ARIZONA: Baboquivari Mountains, April 25, 1947; Sabino Canyon near Tucson, April 27, 1948; Headquarters, Organpipe Cactus National Monument, April 10, 1948, at light; Picacho Peak, May 11, 1942; San Carlos, April 3, 1938 (F. H. Parker); Cave Creek, Maricopa County, July 6, 1941 (F. H. Parker).   CALIFORNIA: San Bernardino County, received from C. W. Johnson, labeled *A. carbonarius* Osten Sacken, and probably collected by Coquillett.

Aphoebantus micropyga, n. sp.

Figure 38

Male.—Length 7.5 mm.   Covered with white pile and tomentum. Eyes contiguous one-fifth the way to the antennae; upper occiput and front argenteous, frontal pile white, parted, continuous except on the bare orbits, with many white scales intermixed, face strongly receding, white, wholly covered with white pile and many scales; scales of orbits white, mostly contiguous; antennal hairs white, base of third joint piriform, longer than deep, merging into the short styliform apex; proboscis not projecting, palpi fuscous.   Notum somewhat trivittate because of wider scales on the stripes, pile dense in front of the wings, tomentum clustered above the wings, notal pubescence abundant and white, bristles weak and white; scutellum covered with white scales, postalar declivities slightly glaucous; pleura cinereous, the hairs and scales white.   Pygidium inverted, heavily covered with white scales, the caudal disks round, black with yellow rim.   Coxae and femora black, white-tomentose, the knees broadly and the rest of the legs yellowish, front and hind femora beneath and the middle femora posteriorly with white hairs, tibial bristles pale, no long metatarsal spine.   Veins mostly yellow, apex of the first posterior cell two-thirds width at middle, sections of fifth vein 1 : 2; halteres yellow.

Female.—Thorax and abdomen unusually pilose; upper front half as wide as at antennae, the frontal pile and scales with yellowish tinge.

Holotype and *allotype:* Wellton, Arizona, April 15, 1938 (F. H. Parker). *Paratype:* A mutilated male taken on the sand dune north of Rocky Point, at kilometer 99, Sonora, Mexico, April 21, 1948.

Aphoebantus mixtus Coquillett

A female from Yaqui Pass in the Borrego Desert, California, April 3, 1946, seems to belong to this species, the discrepancies being the presence of some white tomentum on the face, absence of yellowish scales on the abdomen and the scutellum not opaque though it is covered with pale yellow scales. Apparently the scales of the mesonotum are paler and the bristles of the hind tibiae are darker than in the type. The differences in color are not important, but the shining basic tone of the scutellum may indicate that the specimen is not *mixtus*.

Aphoebantus mormon, n. sp.
Figure 35

Male.—Length 10 mm. Eyes contiguous third-way to the antennae, ocellar triangle black, with fine black hairs; front argenteous, its pile fine and white but with coarser black hairs in the middle, tomentum sparse and whitish, orbits bare; face white-pruinose, white-pilose over all, tomentum sparse and white; cheeks bare, upper occiput silvery, white-pilose, lower occiput white-pruinose, tomentum and short pubescence white; base of antennae cinereous, with small black hairs above and white hairs below, the third joint with subglobular base, the abruptly cylindrical end one-half longer than the bulb; proboscis short, fleshy, palpi fuscous. Thorax dull gray, tomentum pale yellow, the scales a little broader along three dorsal vittae, bristles in front of wings yellowish, those in back of wings, before the scutellum and on the scutellar margin strong and black, dorsal hairs scattered and black, anterior and lateral pile whitish; postalar declivities cinereous; pleura white pruinose, the pile and tomentum white. Abdomen with lateral pile white and about as long as the segments, dense on the first segment, dorsal hairs suberect and localized on the posterior half of each segment, white, but those of the seventh segment black and decumbent; tomentum abundant, matted, fulvous, forming a median row of five rather indefinite brown spots, incisures narrowly marked with white scales; venter closely white-tomentose; harpagones slightly cinereous, furnished with whitish scales and many downward-curved blackish coarse hairs which project beyond the pygidium, apically ending in a long rufous deflexed uncus, the pair of caudal flaps rufous, ventral piece not tapering but the rufous upper edge acutely produced behind, tomentum white. Femora mostly black, tomentum white, bristles somewhat reddish, tibiae and tarsi luteous, the spines of the hind tibiae strong and blackish. Wings hyaline, veins brownish, spur of third vein as long as the angulation, first posterior cell about one-third as wide at the apex as at the middle, sections of fifth vein 2 : 3; knobs of halteres dusky, stalk yellowish.

Female.—Front black, its hairs all black, face more cinereous, upper occiput blackish, slightly cinereous and furnished with scattered yellowish tomentum. Abdomen not pilose, the dorsal hairs black along the hind margins of the segments.

Type and *allotype:* Parowan, Utah, August 1, 1919. *Paratypes:* Twelve males from Anderson's Wash, July 29, and Dry Canyon, August 3, Iron County, Utah, all received from Dr. H. Hagan; a male and a female from Bloody Basin, Yavapai County, Arizona, September 14, 1947, and two females from the White Mountains, Arizona. September 21, 1936 (F. H. Parker).

This species may be the form misidentified as *cervinus* by Coquillett. It differs from Loew's species in having the scutellum entirely dull and tomentose.

Aphoebantus mus Osten Sacken
Figure 14

This species has been recorded from California, Arizona, Utah and Mexico, and I have specimens from all but the last of these localities. The males have an abundance of long white pile and except for the black scales of the abdomen are almost devoid of tomentum. All the femora have long white hairs, but they are not conspicuous in the females. The females have narrow bands of white scales on the abdominal incisures. Hairs of underside of first antennal joint white; ground color of thorax and scutellum bluish gray; bristles pale.

C. V. Riley has reported the rearing of this species from larvae that were living in the egg-pods of Californian grasshoppers. The larvae were voracious feeders, destroying the several dozen eggs in the pod and pupating beneath the spent egg-shells.

The species is similar to *hirsutus*. Coquillett first described the female of that species as having yellowish fasciae on the abdomen almost as wide as the bands of black scales, and later designated the fasciae as white. *Hirsutus* has light yellow halteres and the anterior tibiae of the male are fringed with white hairs. Male specimens identified by Coquillett as *hirsutus* and *mus* are almost indistinguishable from each other, but the one he named *hirsutus* does have the tibial fringe while none of my specimens of *mus* show such hairs.

Aphoebantus mus var. barbatus, nov.

Male.—Length 8 mm. Eyes separated the width of the front ocellus; facial hairs black with a few pale hairs admixed; base of antennae with long blackish hairs. Thorax and scutellum gray-green; abdomen covered with black scales, the hind margin of segments two and following each with a distinct row of white scales. Bristles of legs blackish.

Holotype and *paratype:* Headquarters, Organpipe Cactus National Monument, Arizona, April 25, 1948, and from Alamo Canyon in the same park, April 25, 1947, the latter collected by John L. Sperry.

Aphoebantus obtectus, n. sp.
Figure 31

Male.—Length 4.5 mm. Eyes separated the width of the blackish ocellar triangle, where the front is one-eighth the width at the antennae, front completely covered by elongate glistening white scales which even protect the base of the antennae, no frontal pile; face strongly receding, wholly covered by the downward-directed short white pile and tomentum, cheeks coated with forward-directed white tomentum but bare of

hairs; occiput not lobose, the upper tomentum loose; antennae short, the third joint conical with tapering tip; proboscis wholly retracted, haustellate.   Thorax thinly dusted with cinereous, the tomentum white on front, sides and the margin of the scutellum, and pale brownish on notal disk, hairs sparse, whitish, bristles brown; scales of pleura coarse and white. Abdomen laterally and at base with open white pile, hind margins of segments fasciate with white scales some of which are attached to the anterior corners of the segments, dorsum otherwise with fulvous scales, venter with white scales open enough to show the black integument between them and continuing over the small ventral piece of the pygidium, harpagones very small and retracted. Legs blackish, the knees and anterior tarsi somewhat brownish, scales white, underside of hind femora with about four fine hairs toward base and two bristles toward knee, middle femora posteriorly with white hairs. Veins brownish, third vein without spur, sections of fifth vein about 2 : 3; halteres whitish except root.

Holotype: on sand dunes just north of Point Penasco at the head of the Gulf of Lower California, Sonora, Mexico, April 21, 1948. *Paratypes:* One taken with the type; one from Travertine Rock at Salton Sea, California, April 3, 1946; one from the sand dunes at Antioch, California, June 25, 1947; one from Roosevelt Lake, Arizona, May 2, 1937 (F. H. Parker); and one from Riverside, California, August 24, 1936 (C. M. Dammers, in Citrus Experiment Station).

By the dense tomentum of the front which completely obliterates the ground structure and suppresses the development of frontal pile, this species appears to be closely related to *pavidus* Coquillett, but Coquillett's species has contiguous eyes in the male and a large pygidium. The description also states that the bands of white tomentum are located at the base of the abdominal segments excepting the first where the band is at the apex. The species name, *obtectus*, refers to the dense glistening covering over the front, the individual scales of which measure about ten times as long as wide.

Aphoebantus parkeri, n. sp.
Figure 30

Male.—Length 10 mm. Eyes contiguous third-way to the antennae, upper occiput and front heavily white-pruinose, almost argenteous, front pilose almost to the eyes, middle hairs black, the other hairs and the sparse tomentum whitish, face greatly receding, white-pollinose, completely pilose, the hairs white, a very few elongate white scales; occiput strongly cinereous-white, the scales white; antennae lightly cinereous, the upper hairs of base dusky, bulb of third joint not larger than the first joint, rather globular, the abruptly thin styliform process about one and one-half times as long as the bulb; proboscis not projecting, fleshy, palpi fuscous.   Thorax and scutellum dull gray, tomentum yellowish, pile whitish, bristles in front of wings pale yellow, the others and those of scutellum black and strong, postalar declivities like the notum; pleura strongly cinereous, tomentum and hairs white. Abdomen narrowed at fifth segment, tomentum yellow above and white below, hairs white, dense on first segment as usual; pygidium bluntly conical, the harpagones nearly twice as long as wide, bearing short stiff

yellow hairs and a few yellow scales, the deflexed apex surpassing the ventral sheath which bears a few white scales and in ventral view is cordate and somewhat wider than long, caudal disks yellow. Legs black, the knees narrowly yellowish, coxae and femora with white scales, bristles yellowish, no metatarsal spine. Veins mostly black, luteous at the base, spur of third vein long, first posterior cell one-fifth as wide at tip as at middle, fifth vein ratio 1 : 2; halteres yellowish or light brown.

Female.—Front blackish, one-third as wide at vertex as at antennae, all hairs black; occiput cinereous. Abdomen unlike the male in color of the scales, those of the dorsum of the second segment white at base, merging through yellow to brown and on the hind border white. The dark band occupies two-thirds of the second segment. The subsequent segments have mostly brown tomentum merging to yellow on the sides. Venter and deflexed sides of the tergites white-tomentose.

Holotype: South Fork Camp, White Mountains, Arizona, June 25, 1947 (John L. Sperry). *Allotype:* Canyon Lake, Arizona, September 2, 1935 (F. H. Parker). *Paratypes:* Seven males, White Mountains, Arizona, June and July (Sperry and Parker); Globe, Arizona, June 7 (F. H. Parker); Parowan Canyon, Iron County, Utah, July 30 (Harold Hagan).

It is gratifying to dedicate this species to Frank H. Parker, a careful collector and student of Arizona insects. Mr. Parker has assembled twenty-nine of the species dealt with in this paper, a fine record for Arizona, from which State only one species was heretofore known.

A. parkeri resembles *conurus*, but is easily differentiated by its dull scutellum which is evenly covered with yellow tomentum and shows no concentration of scales at the apex. Its pygidium has fewer scales and setiform hairs than *conurus*.

Aphoebantus pellucidus Coquillett
Figure 16

The female is easily recognized by the polished tubular seventh segment of the abdomen. The male, hitherto undescribed, does not resemble the female, appearing whitish gray instead of yellowish. The male has the thorax coated with matted white hairs and the abdomen with elongate white scales. The fine pile of the abdomen is long, abundant and white. The reddish margin of the ventral pygidial plate rounds from above to the rear and is devoid of tomentum. Upper occiput and front argenteous, frontal, facial and ocellar pile delicate, short and white; a few white scales on front and face between the pile. In the female the front is two-thirds as wide above as at the antennae and is densely coated with yellow tomentum and short pile.

Borrego, April 25 and May 2 (J. L. Sperry); Palm Springs, May 6, and Joshua Tree National Monument at Hidden Valley, May 20, all in Southern California.

Aphoebantus peodes Osten Sacken
Figure 21

Body often more shining black than usual; pile of abdomen short, incisures with narrow fringe of white tomentum, pygidium dorsally with

a prominent basal triangular sclerite; stalk of halteres brownish, knob ivory white; third vein without appendage.

Originally described from a pair taken in Northern Sonora. Cole has reported its occurrence at Hood River, Oregon. I have taken a male and two females at Sheep Creek Canyon, about three miles south of Phelan, California, on April 25, 1946; and two males and five females on the sands at the junction of the South and East Forks of the Santa Ana River, elevation 6250 feet, in the San Bernardino Mountains, California, at various dates during May. If all these are the same species the fly has an unexpectedly extended distribution.

Aphoebantus rattus Osten Sacken

A female from the Vekol Valley in Southern Arizona, April 7, 1935, seems to be this species, which was originally described from Dallas, Texas. It closely resembles *Epacmus tomentosus*, but the labellae are somewhat shorter. The face is black. The bases of the tibiae are reddish, whereas the legs of the type are described as black. The veins are heavy and blackish, except the costa, subcosta and first vein which are yellowish. In *tomentosa* the veins are thin.

Aphoebantus scalaris, n. sp.
Figure 42

Male.—Length 7 mm. Eyes contiguous two-fifths the distance between ocelli and antennae, frontal orbits silvery and bare; face strongly receding, almost silvery, uniformly covered with fine silky white pile; occiput white-tomentose below, becoming silvery above; hairs at base of antennae white, bulb of third joint about as long as the abruptly styliform part. Mesonotum rather shining, loosely coated with white tomentum, the white pile moderately dense: pleura more cinereous, with scattered white scales; scutellum shining, the base with loose white tomentum; thoracic and scutellar bristles long, fine and pale. Abdomen constricted, shining, coated with scales and clothed with long white pile especially dense on base and sides; narrow hind margins white-tomentose, the basal white fascia most pronounced, mid-dorsum otherwise black-tomentose, sides broadly and loosely white-tomentose, venter closely white-tomentose; seventh tergite with an apical fringe of white hairs; pygidium black, not large, no longer than the fifth segment, characterized principally by the strong downward-curving end to the claspers, at the upper base of which is a pronounced acute lobe, ventral piece tomentose, notched laterad the caudal disk. Legs with white tomentum, hind femora beneath with about ten delicate hairs which are in length about the diameter of the femur, tibiae setulose. Wings clear hyaline, veins testaceous, the first vein and apical parts of the others darker, third vein without appendage; calypteres white.

Female.—Front shining above, subshining below, the lower half of the frontal orbits and the whole of the face white-pruinose; black pile of the front more extensive than in male; upper occiput less silvery. Pile of body short and less dense; the fasciae of black tomentum extending across the widened abdomen.

Type and *allotype:* Travertine Rock, on the west side of Salton Sea, California, April 3, 1946. *Paratypes:* One male, Cajon, California,

June 28, 1945; one male and two females, Headquarters, Organpipe Cactus National Monument, Arizona, April 10–12, 1948, the male collected by John L. Sperry.

This is an extreme form of the *marginatus* complex. Its black frontal pile in both sexes, wholly black legs or at most the hind tibiae and tarsi brown, dusky halteres, largely black-tomentose abdomen with the hind margins of the segments narrowly fringed with white scales make a combination of characters enough at variance with the variations found in *marginatus* to entitle the form to species rank. *Scalaris*, Latin, like the rungs of a ladder, referring to the cross-bars of white scales on the black-tomentose abdomen.

Aphoebantus scriptus, Coquillett

I have taken two females that agree well with the description of *scriptus*, except that the face has a few scattered whitish scales and the black-tomentose fasciae are limited to segments two, three, and four of the abdomen. One of these, from Furnace Creek, Death Valley, California, April 23, 1935, measures 9 mm. The other, from the Gila desert south of Welton, Arizona, April 8, 1935, is only 7 mm. in length. Coquillett did not mention the size nor the locality for his specimens.

Aphoebantus sperryorum, n. sp.

Figure 26

Male.—Length 9.75 mm. Front and face golden pruinose, orbits bare, hairs golden, stiff, absent just below antennae: occiput golden pruinose behind eyes, elsewhere blackish in ground color but luteous behind oral cavity, heavily coated with orange-colored tomentum except the cinereous ventral part; ocellar triangle black; antennae wholly luteous, basal joints with yellow hairs; third antennal joint 2.25 times as long as deep, nearly straight above, concave below, style microscopic; proboscis not projecting, luteous, palpi yellow, two-jointed, three-fourths as long as the proboscis, the labellae fleshy and as long as the base of the proboscis. Thorax with mesonotum blackish, heavily overlaid with orange tomentum, bristles orange-colored, scutellum like notum; pleura with reddish tinge, tomentum yellow; hairs short, scattered, yellow. Abdomen orange in ground color, heavily covered with concolorous scales, hairs coarse, deep yellow, located near the hind margins of the segments above, clustered on the first segment and laterally on others, venter with yellow scales, its hairs scattered; pygidium larger than rest of abdomen, covered with long scales, upper valves ending above in a long talon, ventral piece acutely continued posteriorly on each side, behind with a large elliptical matte rufous disk on each side of the base of the slender arcuate penis. Legs luteous, hairs, bristles and tomentum concolorous, trochanters with small apical brown spot, middle femora with posterior patch of distally directed hairs, hind femora setose beneath, hind metatarsi with prominent subapical bristle· pulvilli minute. Wings hyaline, veins and subcostal cell luteous, hairs on base of costa black, branch of third vein with strong spur, sections of fifth vein proportioned 2 : 3; halteres luteous, the knob flavous; alulae luteous.

Female.—Front wholly covered with coarse orange hairs and tomentum, occiput with tomentum reaching eyes; third antennal joint turnip-shaped, the base more bulbous than in male, one and one-half times as long as deep. Abdominal hairs less evident. Spur of the third vein forming a square cell.

Type and *allotype:* Borrego Desert, April 26, 1946, taken near a water hole by John L. Sperry. The species is certainly closely related to *abnormis*, notwithstanding the difference in antennal shape which heretofore would have placed them in two genera. Both have the compressed pygidium, with elongate appressed elliptical caudal plates and both agree in general structure and vestiture. It is with great satisfaction that I may dedicate this most striking fly to my friends Grace H. Sperry and John L. Sperry, whose energy in collecting the insects of the southwest and whose generosity in sharing them with others is appreciated by many entomologists.

Aphoebantus tardus Coquillett

Figures 45, 46

Halteres wholly pale yellow; pygidium not exceeding the last two segments in length, the dorsal triangle small or undeveloped; bristles in back of the wings and those of the scutellum long, thin and pale; third vein without appendage, veins flavous; hind femora with two small preapical bristles.

Coquillett had four males and five females from Los Angeles, San Diego and Kern Counties, California. I have taken five males and three females at Travertine Rock on the west side of Salton Sea, Piute Butte in the Mojave Desert, Palm Springs and Antioch, all in California; one male in the Alamo Canyon, Ajo Mountains, Southern Arizona; a female in the Yoko Valley, Arizona; and seven males and two females on the sand dunes just north of Puente Penasco, Sonora, Mexico, the last taken on April 21, 1948. With the Sonoran specimens were also one male and six females that differ from the typical form in that the pile of the face is yellowish instead of black, and the pile of the front of the male is of the same yellowish color as that of the face. I have taken the same pale bearded variation also at Travertine Rock and at Antioch, where the two forms occurred together. Frank H. Parker has sent me specimens of *tardus* from Palo Verde, Aztec, Wellton, and the White Mountains, Arizona, and the pale bearded form from Palo Verde and Wellton. Professor Timberlake has taken the typical *tardus* in the vicinity of Riverside on *Adenostoma*, and the pale bearded form at Palm Springs, Warner's Springs and near Newberry, all in southern California.

The pygidium of this species shows a tendency to gape, in which case it presents a very different appearance from the closed condition. Ordinarily the upper corners of the ventral plate project to a greater or less degree. When exploded, the ventral plate is flattened so that the upper corners are lowered and are covered by the pushed-out hairy lamelliform apex of the ventral piece. The penis is then visible as a filiform projection from the base of the harpagones. See figures.

Aphoebantus timberlakei, n. sp.

Figure 22

Male.—Length 7 mm. Eyes almost touching, the separation much less than the diameter of a facet; front and upper occiput argenteous, frontal pile and intermixed scales white, orbits bare; face white-pruinose, bare on upper half; occiput grayish white, the scales white, dense along middle orbits; basal antennal hairs short, white, third joint conical, two and a half times as long as deep, the inner face gouged; proboscis slightly projecting, labellae somewhat up-turned, palpi yellowish. Shoulders with a large square of white tomentum extending back along suture over wings, elsewhere the tomentum pale fulvous as well as over the whole scutellum; postalar declivities cinereous and rugose; bristles yellowish, dorsal pubescence short and colored like the tomentum; pleura cinereous, the scales and hairs white. Abdomen stubby, pile rather long and abundant, whitish, dense at base, tomentum light fulvous above, white on inflexed sides and venter; pygidium robust, without tomentum, corners of ventral piece rectangular. Coxae and femora black, coated with white scales, tibiae reddish brown, tarsi brown, anterior femora posteriorly with some pale hairs, bristles of hind femora yellowish; apical seta of hind metatarsus of same length as tibial spines. First posterior cell twice as wide at middle as at apex, underside of discal cell strongly sinuous, sections of fifth vein 1 : 3; black costal setulae not reaching base of wing; halteres yellowish, mottles.

Holotype: The Gavilan, Riverside County, California, May 31, 1937, on the wild buckwheat, *Eriogonum fasciculatum*, in the collection of the Citrus Experiment Station. The species is named in honor of the collector, Professor Philip Hunter Timberlake, in recognition of his paintaking interest in the relation of flowers and insects.

Aphoebantus transitus Coquillett

Figure 44

This species, originally placed in *Epacmus*, is easily recognized by the characters in the key. Face slightly projecting, front of male argenteous; labellae compressed; the thin styliform part of last antennal joint twice as long as bulb; eyes of male slightly separated. Sides of thorax white-tomentose, dorsum yellow-tomentose; the black hairs of male abdomen erect and long. Wings more infumated than in the other species, the darkening extending from end of first vein obliquely through apex of second basal cell.

Lovejoy Butte in Western Mojave Desert, March 25, 1947; Claremont (C. W. Metz); Perris, April 8 (Timberlake); The Gavilan, April 1 (Timberlake); Edom, March 14 (Timberlake); Oak Grove, May 8, 1945 (legs of female yellowish); East Fork of Santa Ana River, elevation 6300 feet, May 9, 1946: all in Southern California.

Aphoebantus ursula, n. sp.

Figure 27

Male.—Length 8 mm. Eyes contiguous one-sixth the distance to the antennae, upper occiput and front silvery, rest of occiput cinereous and white-tomentose, frontal pile white, parted, orbits bare, face

strongly receding, white-coated, pile reaching almost to antennae, white, no tomentum on face or front; base of the antennae cinereous, bulb of third joint about equal to the first joint, the abruptly styliform process about twice as long as the bulb; proboscis not projecting, palpi fuscous. Thorax dull gray, the tomentum and pile white, bristles whitish; pleura heavily cinereous, scales white, dense on the sternopleura. Black scales of abdomen extending about halfway across the front border of the segments, elsewhere the scales are large, abundant and white, pile long, white and distributed over the segments, venter densely coated with white scales; pygidium as long as three preceding segments combined, harpagones nearly three times as long as the basal width, glaucous, the basal half with many long white scales but almost no hairs, ventral sheath white-tomentose, with few hairs, bending above against the harpagones and projecting beyond them, the corners forming an angle of about 75 degrees and broadly luteous. Coxae, femora and tibiae with many white scales, long hairs of hind femora not abundant, spines brownish, the terminal spine of hind metatarsus one-sixth as long as the joint. Veins blackish, apex of first posterior cell fully half as wide as the width at middle, sections of fifth vein 1 : 3; knob of halteres mostly yellow, the stalk somewhat brownish.

Female.—Length 9 mm. Occiput cinereous black, front subshining black above becoming cinereous below, at vertex about two-fifths as wide as at antennae, pile black but whitish on lower orbits. Spur of third vein small or wanting.

Holotype and *allotype:* Palm Canyon in the Borrego Desert, California, April 2, 1946. *Paratypes:* Five males and six females, Ocotillo, March 6, 1947 (J. L. Sperry); Morongo, April 19, 1937 (P. H. Timberlake, in Citrus Experiment Station); Palm Springs, March 24, 1935; Magnesium Springs Canyon near Indio, April 4, 1946: Twenty-nine Palms, April 22, 1944, all in Southern California.

Ursula, a bear cub, in line with the other animal names used in *Aphoebantus: mus*, mouse; *rattus*, rat; *catulus*, puppy; *vulpecula*, little fox.

Aphoebantus varius Coquillett
Figure 32

Coquillett described the male as being like the female in coloration, with the eyes separated as widely on the front and the genitalia very small. It seems that all his specimens must have been females, because all my males are very different. Coquillett is reported to have relied exclusively on his hand lens for his taxonomic work, and so could have fallen in error when trying to sort the sexes. On May 6, 1946, I collected numerous specimens just southeast of Palm Springs, California, the females, with one exception, agreeing with the original description in having the abdomen and legs yellow, but the males and the exceptional female having the body and legs black, the genitalia of normal build and the eyes of the male contiguous. Although no specimens were taken in copulation it seems certain that *varius* is trimorphic in its various combinations of holopticism, genitalia and coloration. A visit the next year to the same locality found the ground leveled of vegetation in preparation for real estate exploitation. With the vegetation went the *Aphoebantus*, as well as the remarkable *Empidideicus*

previously found there. Professor Timberlake has collected the three forms in various desert localities, near Barstow and near Palm Springs, on flowers of several species of *Eriogonum*.

Aphoebantus vasatus, n. sp.
Figure 24

Male.—Length 5 mm., the range from 3 to 6 mm. Upper occiput, front and face argenteous, the occiput blackish when seen from the rear; eyes separated nearly the width of an ocellus, pile of front and face delicate and pure white, the orbits and a triangular space above the antennae devoid of pile, face bare below the antennae; proboscis slightly projecting, the labellae divaricate, palpi yellowish; basal hairs of antennae white, the piriform base of the third joint as long as the styliform part. Tomentum and hairs of notum, scutellum and dorsum of abdomen yellowish to white, those of front and side parts of the mesonotum and of the inflexed part of the abdomen whitish, of venter and pleura white, abdominal incisures not banded, bristles yellow; mesonotum and postalar declivities rather dull grayish black. Abdomen stubby, rather pilose, the hairs dense and white on the sides of the first segment and erect over the dorsum; pygidium without long hairs, the ventral sheath with some short caudally directed pubescence, the upper edge inflexed to adapt to the lateral incisions on the wide harpagones, the posterior corners rounded. Legs wholly black except the knees narrowly, terminal bristle of hind metatarsus minute. Wings normal, veins brown becoming black in back, costal setulae extending to base of wing, third vein without spur, first posterior cell scarcely narrowed apically, sections of fifth vein 1 : 2 to 1 : 3; halteres ivory, the stalk yellowish.

Female.—Occiput full and deeply sulcate, blackish; frontal pile paler toward antennae; abdomen not pilose but with scattered hairs; tibiae fuscous.

Holotype and *allotype:* Sheep Creek Canyon, five miles south of Phelan, California, April 24, 1946. *Paratypes:* Two females, Morongo Inn, California, May 10, 1935. Professor Timberlake has taken the species also at Morongo, on April 22, 1937, on *Cryptantha*. *Vasatus*, Latin, having a large pygidium.

Aphoebantus vittatus Coquillett
Figure 33

A pretty species, 4 to 6 mm. in length, distinct by its mid-dorsal and lateral stripes of white scales on the abdomen and two similar vittae on the mesonotum, continuing on the sides of the scutellum. The sides of the notum are also white-tomentose, leaving the three broader intervening stripes coated with blackish tomentum. The upper surface of the abdomen is almost completely covered with black or dark brown scales, except for the clearly delimited white vittae. The tomentum of the front is dense, either pure white or mixed with brownish. The halteres are dark.

I have taken three specimens of this well-marked species in the Mountain Home Canyon, at 5000 feet elevation, in the San Bernardino

Mountains, late June, 1948. Professor Timberlake has a specimen from Riverside, California, June 9, 1938, found on *Hugelia*.

Aphoebantus vulpecula Coquillett

Figure 23

I have thirty-nine specimens which run to *vulpecula* in Coquillett's table and agree with his brief description. The face is full, scarcely receding; the bristles of the scutellum and rear of thorax are yellow or reddish; and there is a small epaulette of white scales at base of the costa. The localities represented are, CALIFORNIA: Borrego and Palm Springs. ARIZONA: Ligurta, Wellton, Picacho, Gila Bend, Organpipe Cactus National Monument and Tucson; Ajo, Hayden, Roosevelt Lake and San Carlos (the last four from F. H. Parker). SONORA, MEXICO: 25 kilometers south of the Border on the road to Rocky Point. All specimens were taken during April and early May.

AMERICAN SPIDERS, by WILLIS J. GERTSCH. xiii+285 pages, 32 plates in color, 32 in black and white. D. VanNostrand Company, Inc., New York. 1949. Price, $6.95.

Popular works on spiders by competent writers are practically non-existent in American literature and, in order to find anything remotely comparable to Dr. Gertsch's "American Spiders," one is obliged to go back to Emerton's "Common Spiders of the United States," first published in 1902 and long since out of print, or to the natural history sections of J. H. Comstock's "The Spider Book."

The kind of information provided in "American Spiders" is that which should have its greatest appeal to the amateur naturalist and layman; but there is information to enlist the interest of the specialist as well. Unencumbered by detailed classification, the emphasis is upon accounts of the place of spiders in nature and in chapters on web-spinning, courtship and mating habits, evolution and economic and medical importance. Special groups of spiders, which because of some peculiarities of structure or habits are especially interesting, are treated in considerable detail.

The book is beautifully illustrated with 32 plates in color (not forty-four as indicated in the jacket blurb) and an equal number in black and white (not sixty-seven as claimed). Most of the illustrations are successful but color plate 16 could have been omitted without detriment for the three figures composing it are all out of focus.

One must indeed be hypercritical to find fault with the volume but since no first printing is without errors, attention may be called to a few minor items in need of correction. The word 'beautiful' on p. 18, line 2, is misspelled; the reference to a porcupine shooting its quills, p. 29, will scarcely find support among vertebrate zoologists; and the statement on p. 120 that there are no tarantulas in Florida and the southeastern States is contradicted on p. 133 where it is pointed out that some atypical species are found in Florida and Georgia. Plate XXVIII, facing page 211, has the figure of *Dolomedes*, not plate XXVI as indicated on page 206; and the specific name, *Dolomedes okefinokensis*, page 207, should be spelled with an "i," as it was, *with intent*, in the original description, in spite of the fact that the name of the swamp is spelled "Okefenokee," by decision of the U. S. Geographic Board.—SHERMAN C. BISHOP.

[Another slight error is the use of the term "bee fly," in Plate XXXII, for an insect which any dipterist will recognize as a syrphid.

The cost of the book is undoubtedly due in part to the illustrations. These are the work of such photographic artists as Lee Passmore, J. M. Hollister, Walker Van Riper, and others.—EDITOR.]

A NEW ORCHOPEAS JORDAN (SIPHONAPTERA) FROM THE FOX SQUIRREL, SCIURUS NIGER LINNAEUS

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The tree squirrel, *Sciurus niger* Linnaeus, is frequently heavily parasitized by fleas. Typical specimens of the common tree squirrel flea, *Orchopeas howardii* Baker, make up about half of the large Texas
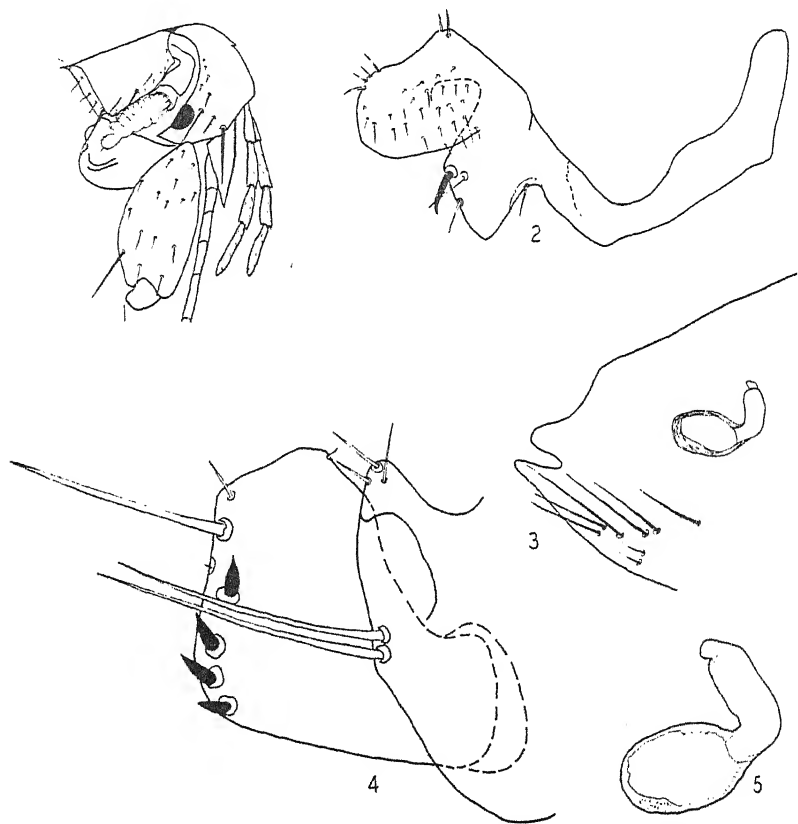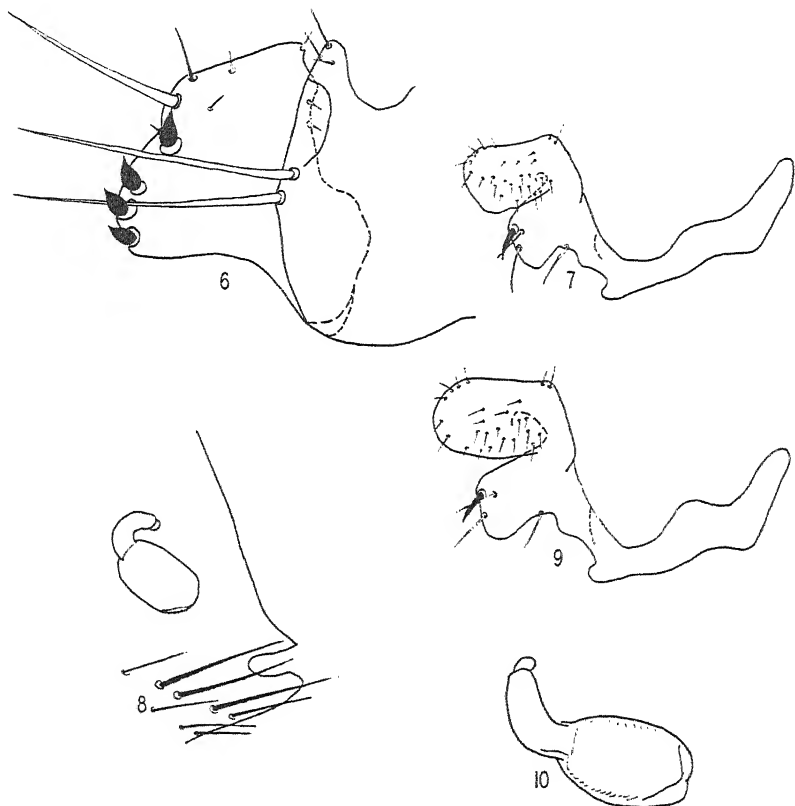

Orchopeas howardii texensis, n. subsp. Fig. 1. Head of male. Fig. 2. Sternite IX of male. Fig. 3. Sternite VII of female. Fig. 4. Movable finger and clasper of male. Fig. 5. Female spermatheca.

series examined. The remainder of the specimens are obviously related to *howardii*, but differ in a number of minor but apparently constant characters. This segregate of *howardii* seemingly is entitled to at least subspecific recognition. The essential differences are included in the following description.

Orchopeas howardii texensis, n. subsp.

Holotype male.—Labial palpi reaching fore femora; preantennal bristles in one distinct row, three in number with the middle one much shorter than the outer two; dorsal to this ocular row and on ventral margin of the antennal fossa is a short bristle and a series of about eight small setae along ventral margin of antennal fossa; eyes prominent, well pigmented; genal process acuminate; postantennal region with

Orchopeas howardii howardii Baker. Fig. 6. Movable finger and clasper of male. Fig. 7. Sternite IX of Texas male. Fig. 8. Sternite VII of female. Fig. 9. Sternite IX of Oklahoma male. Fig. 10. Female spermatheca.

numerous small setae and three bristles along the dorsal margin of the antennal fossa in addition to the row of one large bristle and three smaller ones on the posterior margin of the head.

Pronotum with a ctenidium of eighteen spines and on each side a row of five bristles alternating with fine setae; mesonotum with three rows of bristles, the median row irregular, anterior row of fine bristles and the posterior row with large bristles alternating with fine ones; metanotum with three rows of bristles and two caudal teeth per side; pleuron of mesothorax with seven bristles, the ventrocaudal one the

largest; episternum of metathorax with one large bristle, epimeron with three large and three small bristles.

Abdomen: Each tergite with two rows of bristles on segments one to seven, anterior row of only two or three small bristles, posterior row of large ones with small setae intercalated between them; tergites one to four with two caudal teeth; three antepygidial bristles, median one stout and over twice as long as outer ones; for details of IX sternite, clasper and movable finger see figures 2 and 4.

Length: Average of five males (on slides) 2.2 mm.

Allotype female.—Preantennal bristles in one distinct row, three in number, as in male, with one short bristle above this row; six small setae along ventral margin of antennal fossa; postantennal region with one large bristle in addition to the marginal row of a large bristle and four small ones; seventh sternite divided by a deep sinus into two lobes, the dorsal lobe blunt apically; tail of spermatheca slightly longer than the body.

Length: Average of five females (on slides) 2.4 mm.

Holotype male and *allotype* female collected by D. C. Thurman, December 29, 1946, Menard, Texas (Menard County), ex *Sciurus niger*.

Paratypes.—Two females and one male collected as holotype and allotype; four males collected in Liberty Hill, Texas (Williamson County), March 23, 1946, by R. W. Strandtmann; two males and four females in Medina County, Texas, January 6, 1946, by C. J. Burgin. All types are from *S. niger*.

Holotype and allotype have been deposited in the United States National Museum and paratypes are retained in the collection of the State Department of Health, Austin, Texas.

Characters which separate this subspecies from typical *O. howardii* are as follows: *O. howardii texensis*—labial palpi usually reaching fore femora in both sexes; in male, ventral margin of movable finger of clasper straight, proximal lobe of ventral arm of sternite IX acute ventrally, basal portion of ventral arm of sternite IX below proximal lobe with outer border straight; in female, VII sternite usually with six large bristles and dorsal lobe blunt apically, arm of spermatheca longer than body. *O. howardii howardii*—labial palpi usually reaching only to apex of fore coxae in both sexes; in male, ventral margin of movable finger arcuate, proximal lobe of ventral arm of sternite IX rounded ventrally, basal portion of ventral arm of sternite IX below proximal lobe with outer border sinuous; in female, VII sternite usually with four or five large bristles and an acute dorsal lobe, spermatheca with arm usually shorter than body. These differential characters have been constant in all male specimens examined. However, female *O. h. howardii* exhibit considerable variation. Some of the variants may be difficult to separate from *O. h. texensis*.

STUDIES ON ARTHROPOD CUTICLE

IV. An Electron Microscope Survey of the Intima of Arthropod Tracheae[1]

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A preliminary description of the appearance of the tracheal intima of a few arthropods was given during exploratory work on the application of electron microscopy to entomological problems (Richards and Anderson, 1942a, b; Anderson and Richards, 1942). The present paper is the result of a survey made to determine the number of tracheal types in arthropods and to locate species which are most favorable for an electron microscope analysis of tracheal wall structure. The data presented herein are given to illustrate the range of variation seen in surface views of the intima of tracheae and tracheoles in a representative series of arthropod species. Some discussion is also given on the nature of the forces that might produce tubes of these diverse types, but the extreme difficulty of obtaining critical data on such minute tubes necessarily makes the discussion largely a speculative rationalization. In a subsequent paper we plan to analyze the cross-sectional composition of the tracheal walls of a few representative species in more detail.

METHODS

The membranes of tracheae and tracheoles are readily prepared for examination in an electron microscope by the simple method used in the preliminary survey. This consists of dissecting a living or at least undried specimen and allowing the extirpated tissues to undergo cytolysis in distilled water for a few minutes or some hours. Most of the preparations were prepared in this manner with little attention being given to precise timing since soaking in distilled water at room temperatures has been shown to have no detectable effect on the tracheal intima (Richards and Korda, 1948). In a few species in which the tracheae did not readily clean on soaking in distilled water, weak alkali solutions were used at room temperatures for a short time, but alkali solutions have such destructive effects that all such preparations need to be checked against ones prepared without alkali treatment (Richards and Korda, 1948). Even 5% KOH at room temperature for 10 to 15 minutes can cause some recognizable effects. A few excellent preparations have been obtained from partially rotted dead

specimens that had never dried (*e.g.*, fig. 52) but no method has been found for making satisfactory mounts from dried or preserved material.

Some preparations of cockroach tracheae and honey bee air-sacs were shadow-cast with gold in vacuo. No additional information was obtained from these preparations although the shadows confirmed the fact (already known from curled edges in silhoutte and from stereoscopic pictures) that the darker lines and spots thought to be thickenings are indeed elevated.

The type of mounting employed depended on the size of the tracheae being sought. Large tracheae, after cytolysis of the cells, were usually split open, laid across an electron microscope mounting screen, and allowed to air dry. Smaller tracheae and tracheoles cannot be readily split and require some supporting film since they are not sufficiently large to extend across a number of supporting wires on the screen. Smaller tracheae were prepared by allowing the cells of a selected organ or tissue to cytolyze (usually incompletely), rinsing through several changes of distilled water, then spreading the resulting mass across a collodion or formvar membrane on one of these screens, and allowing to air dry. Systematic examination of such preparations were made in the electron microscope and pictures were made of portions which by chance lay favorably exposed.

Since the cells were cytolyzed and only the intima examined, our data do not cover cell-intima relationships, and do not touch the question of whether tracheoles terminate intracellularly or extracellularly.

The chief limitation to the analysis of electron microscope pictures of the tracheal intima is the question of the precise relationship between measurements made on the pictures and dimensions of the same structures when the trachea or tracheole was in the intact living insect. Calibration of the instrument is accurate to within ±5%, and resolution on the plates selected for illustrations lie in the range of 40–100 Angstrom units (0.004 to 0.010 microns). There appears to be no significant change in the gross dimensions of larger tracheae on removal, treatment, with distilled water, subsequent drying, and moderate electron bombardment. It does not necessarily follow that the same is true for smaller tracheae or for the minute details within larger trachea. Imbibition of water during cytolysis of the cells would be expected to cause some swelling, and collapsing of tracheoles would appear to increase their diameter. Drying and electron bombardment would be expected to cause some shrinkage although for a firmly attached membrane this might only result in tension without a change in gross measurements. In some cases it is possible to determine that certain tubes are collapsed, partially collapsed or uncollapsed, but in many cases we are not certain whether a particular tube has or has not collapsed. At present it is not possible to evaluate these variables in detail. All measurements given in this paper refer to dimensions on the final prints but with the above uncertainties they are not claimed to represent more than order of magnitude.

GROSS STRUCTURE OF ARTHROPOD TRACHEAE

Ripper (1931) in his critical review of arthropod tracheae has ably pointed out that it is not possible to view the tracheae of all arthropod

groups as homologous structures. He discusses and discards the
nephridial, integumental gland and gill theories of origin, and concludes
by proposing that tracheae arose independently in various groups in
response to the need for an internal respiratory surface. This view-
point is also shared by Snodgrass (*in litt.*). Similarities would then
represent an expression of the fact that an exoskeleton can develop
internal tubular systems readily, and that the forces responsible usually
lead to a similar appearing structure irrespective of the function served.
Rigidity together with ready permeability can be obtained by having
a thin-walled tube with supporting thickenings (text fig. 1), although
similar mechanical supports in salivary ducts, the pseudotracheae of
Diptera, etc., show that the need for permeability is not a determining
factor.

Accepting Ripper's arrangements, we recognize ten groups in which
the tracheae or other internal cuticular respiratory surfaces are not
homologous. These are: (1) Onychophora, (2) Araneida, [Scorpionida]
and [Pedipalpia], (3) Acarina and [Ricinulei], (4) Pseudoscorpionida,
(5) Phalangida, (6) [Solpugidae], (7) Isopoda, (8) Symphyla, (9) Diplo-
poda, and (10) Chilopoda and Insecta. Groups within brackets were
not available to us for study, but representatives of nine of these ten
major divisions were. Despite the non-homology, most of these groups
show the same basic structure: a tubular form, usually branched, with
supporting thickenings which are almost always oriented into bands
called taenidia (the "spiral thread" of many authors; Remy, 1925).
The exceptions are the Isopoda and at least the most common form
of tube in spiders.

In certain species of terrestrial Isopoda there are "air trees" or
"white bodies" on certain abdominal pleopods. These are short
lobate invaginations of rather indefinite morphology (Becker, 1936;
Herold, 1913; Verhoeff, 1917, 1919; Remy, 1925). These are poorly
developed organs which are respiratory but inadequate for the full
respiratory needs of the animal. They have cuticular walls with
reticulate thickenings which show no preferred orientations (fig. 59).
Perhaps because of the non-tubular structure these respiratory "trees"
usually have not been called tracheae; certainly they do not resemble
the tracheae of insects, etc., in either gross- or micro-anatomy.

The Araneida have tubular structures that are commonly called
tracheae although their respiratory significance has been questioned
by Purcell (1909) on embryological grounds and by Kastner (1929) on
crude experimental data (sealing "spiracles" with vaseline does not
harm *Tegenaria*). Whatever their function, these tubular ducts of
spiders have no circular or helical thickenings in any of the species we
examined; they do have heavy reticulations or an elaborate set of
anastamosing processes that would prevent collapse. Several authors
(*e.g.*, Remy, 1925) have recorded that helical thickenings are found in
the tubes of only certain species of spiders and that the type we found
is the common form. Excellent figures of the more complex type are
to be found in the paper by Kastner; our electron micrographs revealed
no additional smaller details (figs. 61–62). Small lateral branches
and terminal tufts have also been recorded for certain species of spiders
(Bertkow, 1872; Purcell, 1909) but we did not locate such in the species

TABLE I

SUMMARY OF FORMS EXAMINED

Abbreviations: T = trachea; Tl = tracheole; A = air sac.
[1]Data from Dakin (1920); light microscope used.
[2]Richards & Anderson (1942b).
[3]Richards and Anderson (1942a).
[4]Richards & Korda (1948).
[5]Anderson & Richards (1942).

Group	Specific Form	Larva	Pupa	Adult	Figures
[Onychophora]..	[*Peripatus*]............			[Tl][1]	
Araneida.......	*Theridion lepidariorum*..			so-called T	61, 62
	Tetragnatha elongata.....			so-called T	
	Neoscona arabesca.......			so-called T	
Acarina........	*Dermacentor variabilis*[2]..			T, Tl	28
	Argas persicus..........			T, Tl	14, 58
Phalangida.....	Not identified..........			T, Tl	38
Pseudo-scorpionida...	Not Identified..........			T, Tl	30
Isopoda........	*Armadillidium vulgare*..			"air-tree"	59
Chilopoda......	*Scolopendra* sp. [2].......			T	
	Lithobius sp............			T	29
Diplopoda......	*Fontaria* sp.[2]...........			T, Tl	23
Symphyla......	*Scutigerella immaculata*..			T, Tl	17, 18, 19, 60
Thysanura......	*Lepisma saccharina*.....			T, Tl	2
Orthoptera.....	*Melanoplus differentialis*	T, Tl		T, Tl	15, 52
	Ceuthophilus sp.........			T	
Blattaria.......	*Periplaneta americana*[3][4]	T, Tl		T, Tl	(In R. & K.)
	Blatta orientalis.........	T, Tl			12, 25
Phasmida......	*Diapheromera femorata*..	T, Tl			4
Plecoptera......	*Pteronarcys* sp..........			T, Tl	6
Isoptera........	*Reticulotermes flavipes*..			T, Tl	53
Mallophaga.....	*Eomenacanthus stramineus*............			T, Tl	1, 54, 55
Anoplura.......	*Polyplax spinulosa*......			T, Tl	
Ephemerida....	*Hexagenia* sp...........			T	
Odonata........	*Lestes* sp...............			T, Tl	16, 20, 51
Thysanoptera...	*Taeniothrips gladioli*.....			T, Tl	9
Hemiptera......	*Oncopeltus fasciatus*.....	T, Tl		T, Tl	7
	Rhodnius prolixus.......			T, Tl	8, 47
Homoptera.....	*Macrostelus divisus*......			T, Tl	3, 57
	Macrosiphum pisi.......			T	
Megaloptera....	*Corydalus cornuta*.......	T, Tl			5
Neuroptera.....	A myrmeleonid.........	T, Tl			
	Chrysopa sp............			T, Tl	
Mecoptera.....	*Bittacus* sp.............			T, Tl	11
Trichoptera.....	*Hesperophylax designatus*	T, Tl			22
Lepidoptera....	*Galleria mellonella*......	T	T, Tl		26
	Malacosoma americana..	T, Tl			56
Coleoptera.....	A carabid..............			T, Tl	
	Photinus pyralis........			T, Tl	27, 33, 43, 44, 45
	A buprestid............	T, Tl			
	Tenebrio molitor........	T		T	48
	Macrodactylus subspinosus[5].........			T	49, 50
	A scarabaid (May beetle)	T, Tl			
	Calandra oryzae........			T, Tl	46
Hymenoptera...	*Neodiprion lecontei*......	T			
	Camponotus herculeanus.			T, Tl	21, 37
	Apis mellifica[3][4]........	T, Tl	T, Tl	T, Tl, A	31, 32 (R. & A.)

TABLE I—(*Continued*)

Group	Specific Form	Larva	Pupa	Adult	Figures
Diptera........	*Sciara coprophila*........	T, T1	......	T, T1	34
	Tipula abdominalis......	T, T1			
	Culex pipiens[3][5]........	T, T1	T, T1	T	(R. & A.)
	Aedes aegypti..........	T	T, T1	T, T1	24, 35
	Drosophila melanogaster.	T, T1	......	T, T1	10
	Drosophila funebris......	T		A	
	Musca domestica........	T, T1	......	T, A	39, 40, 41
	Phormia regina........	T, T1	T, T1	T, T1, A	13, 36, 42
Siphonaptera...	*Xenopsylla cheopis*.....	......	......	T, T1	

we examined.   If we accept as our definition of a trachea, "a respiratory tube with a cuticular lining," it follows that respiratory significance has to be demonstrated rather than gratuitously assumed.   Certainly the presence of helical or circular thickenings is no evidence of function since such are to be found in tracheae, salivary ducts, pseudotracheae of Diptera and Phalangida, some setae, etc.   It does not seem possible to evaluate the so-called tracheae of spiders until more is known about their functioning.

As for the other groups, the Onychophora and Symphyla are usually stated to lack taenidia, but Dakin (1920) has already recorded that taenidia can be seen in *Peripatus* if fresh material is examined; and we find that thickenings, sometimes reticulate, sometimes oriented as taenidia, are to be found in the minute tubes (presumed to be respiratory) of *Scutigerella* (figs. 17–19, 60).   In certain questionably atracheate mites, minute ducts which have been described as tracheae have been re-interpreted by Grandjean (1937) as gland ducts.   There are a few other forms not available to us for which an absence of taenidia has been reported on the basis of observations with a light microscope (e.g., Collembola, Davies, 1927; *Polydesmus*, Effenberger, 1907), but in view of the uniformity with which we have found thickenings, usually taenidial, in minute tubes in which no thickenings can be detected with a light microscope we suggest that these cases will be shown similar when examined by electron microscopy.

From our examination of forms representing almost all the tracheate groups (Table I), we conclude that all the arthropod groups with internal ducts that are presumably respiratory possess thickenings in the walls of these tubes or sacs.   These thickenings are oriented in the form called taenidia with the exception of those in the isopod crustacea, the spiders, some tubes of Symphyla, and some insectan air sacs.   In truly tubular tracheae, the thickenings are always organized as taenidia irrespective of the diameter of the tube (i.e., including tracheoles) except in the questionable tracheae of spiders and some but not all portions of the tubes of Symphyla.

THE ORIGIN OF TAENIDIA

There have been frequent speculations concerning the mode of origin of taenidia but the cause of the usual structure of helical or circular bands in a thin-walled tube is still not certain.   Old figures of cavities within taenidia must usually have been illusions due to focusing effects.

However, there is at least one case (*Musca*, figs. 39–40) where tubular taenidia do occur and where the structure suggests taenidial origin from a corresponding groove, as Dujardin suggested in 1849. All careful cytological observations show taenidia are not "chitinized" nuclear processes (Packard, 1886). To say taenidia are equal to cuticular ornaments is either untrue or unhelpful depending on what Keilin (1944) meant. There is good evidence that they are not formed (or at least not necessarily formed) around corresponding cytoplasmic modifications which have the function of molding taenidia because they occur on the lumen side of the continuous tubular membrane (Richards and Korda, 1948), may extend without interruption across several cells (*e.g.*, Thompson, 1929), and may appear suddenly and simultaneously along the trachea (Keister, 1948). Thompson's (1929) analogy to a liquid column breaking into droplets is made untenable by our demonstration of the existence of circular taenidial bands causing the beaded appearance he saw in tracheoles. Wigglesworth (1931) has suggested that taenidia might arise from the action of some simple physical force. We favor this last suggestion. A rigorous proof would be difficult if not impossible but recent data do permit carrying the analysis somewhat further.

By both electron microscopy and optical analysis with polarized light it has been shown for cockroach tracheae that the chains of chitin molecules or micelles run longitudinally in relation to the trachea in the basic membrane (which includes the intertaenidial membrane, text fig. 1) and at a right angle to this in the taenidia (Richards and Korda, 1948). It is difficult to conceive of a crystallization (molecular aggregation) producing this effect. Certainly the effect cannot be a product of chitin molecular properties *per se* since the same result is attained in

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EXPLANATION OF PLATE I

Preparations of tracheae and tracheoles from general body tissues except when specific organ is named. Figs 20 and 22 at approximately 5000×; fig. 23 at 11000 ×; all others at 10000 ×.

Fig. 1. *Eomenacanthus stramineus*, adult (No. 397e). Fig. 2. *Lepisma saccharina*, adult, from around gut (No. 240e). Fig. 3. *Macrostelus divisus*, adult (No. 236a). Fig. 4. *Diapheromera femorata*, one day old nymph (No. 196a). Fig. 5. *Corydalus cornuta*, larva (No. 53d). Fig. 6. *Pteronarcys* sp., adult, from ovary (No. 399b). Fig. 7. *Oncopeltus fasciatus*, young nymph (No. 231e). Fig. 8. *Rhodnius prolixus*, adult (No. 446b). Fig. 9. *Taeniothrips gladioli*, adult (No. 236e). Fig. 10. *Drosophila melanogaster*, adult (No. 546a). Fig. 11. *Bittacus* sp., adult (No. 439a). Fig. 12. *Blatta orientalis*, adult, from around crop (No. 545a). Fig. 13. *Phormia regina*, adult, from ovary (No. 554b). Fig. 14. *Argas persicus*, adult (No. 243d). Fig. 15. *Melanoplus differentialis*, first instar nymph (No. 564e). Fig. 16. *Lestes*, sp., adult (No. 412b). Fig. 17. *Scutigerella immaculata*, adult head (No. 305a). Fig. 18. *Scutigerella immaculata*, adult head (No. 305b). Fig. 19. *Scutigerella immaculata*, adult head (No. 303e). Fig. 20. *Lestes* sp., large nymph, from gill (No. 734e). Fig. 21. *Camponotus herculeanus*, adult worker (No. 237b). Fig. 22. *Hesperophylax designatus*, larva from gill (No. 753b). Fig. 23. *Fontaria* sp., adult (Anderson No. 697a). Fig. 24. *Aedes aegypti*, adult, from ovary (No. 233c). Fig. 25. *Blatta orientalis*, adult, from around crop (No. 545b). Fig. 26. *Galleria mellonella*, young pupa, from wing (No. 26a).

PLATE I
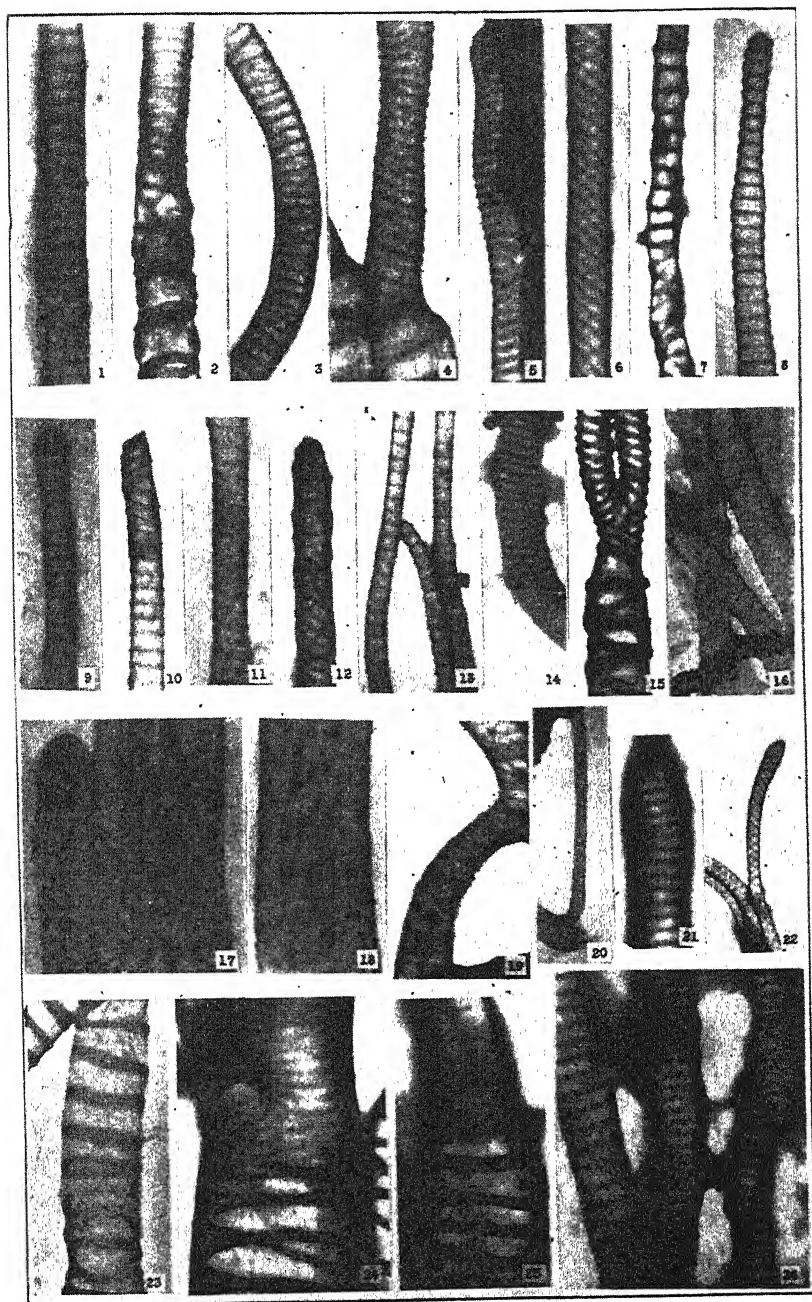
tracheae with and without chitin.[2]   Engineers tell us that the strongest way to make a tube of minimum weight from fibrous components is to have the fibers run longitudinally in the tube wall and then put bands of fibers at intervals around the tube.   This corresponds precisely with the fibrous molecular orientations we have demonstrated in cockroach tracheal walls.   Arguing backwards from this, one is led to suggest that stress forces in the tracheal wall during the viscous plastic stage orient the elongated particles (molecules or micelles) in this manner. The origin of the necessary stress tension, however, is not known, and it does not seem profitable to speculate further while we know neither the magnitude or origin of applied stresses nor the force required to orient molecules in a tracheal wall.

Some modification (not necessarily a great one) will be required to account for the tubular taenidia found in the adult housefly (figs. 39–40) and seen less clearly in certain other species of Diptera.   That these are indeed tubular is shown not only by the density pattern[3] but also by the fact that the tubes or deep grooves are capable of being opened and flattened without apparent tearing in the course of making mounts (does not follow that they can open and close in the living insect). In the housefly, the tracheae are comparable to a pipe with a corrugated wall rather than a pipe with bands.   Solid taenidia occur in the small tracheae and tracheoles of houseflies, and seemingly in at least some of the large tracheae of larvae.[3]   There are several reasons for thinking

[2] We performed chitosan color tests on a few of the species.   Positive tests demonstrating the presence of chitin were obtained for the larger tracheae of *Periplaneta*, *Blatta*, *Galleria*, *Calandra*, *Culex*, *Aedes*, *Neodiprion* and the larvae (not adult) of *Phormia*.   Complete dissolution in the hot alkali, routinely interpreted as indicating the absence of chitin, was obtained for minute tracheae and tracheoles of all species and for the large tracheae and air sacs of *Rhodnius*, *Apis*, *Sciara*, *Drosophila*, *Musca*, adult (not larvae) *Phormia* and *Xenopsylla*.

[3] This statement is based on the fact that electron microscope pictures are density shadow pictures due to electron scattering.   When a thickening shows a uniform density it must be solid.   Thickenings which are corrugations should show dark edges and a lighter central line, just as lumps which are solid show homogeneity (fig. 48) whereas ones which are pimples show as dark circles (fig. 50).

EXPLANATION OF PLATE II

Preparations of tracheae and tracheoles from general body tissues except when specific organ is named.   Figures 27, 32, 33 and 38 at 5000 ×; all others at 10000 × magnification.

Fig. 27. *Photinus pyralis*, adult male, from light organ (No. 450b).   Fig. 28. *Dermacentor variabilis*, adult (Anderson No. 698a).   Fig. 29. *Lithobius* sp., adult (No. 543b).   Fig. 30. Pseudoscorpion, age unknown (No. 466e).   Fig. 31. *Apis mellifica*, pupa (No. 444b).   Fig. 32. *Apis mellifica*, adult, note transition of taenidia (No. 459a).   Fig. 33. *Photinus pyralis*, adult, from around hindgut (No. 454e).   Fig. 34. *Sciara coprophila*, fourth instar larva, dorsal longitudinal trunk (No. 529a).   Fig. 35. *Aedes aegypti*, adult, from ovary (No. 232e).   Fig. 36. *Phormia regina*, adult, from around ovary (No. 554e).   Fig. 37. *Camponotus herculeanus*, adult (No. 238b).   Fig. 38. Phalangid, adult, showing five tubes intertwined (No. 754d).   Fig. 39. *Musca domestica*, adult, most taenidial tubes "opened" (No. 37c).   Fig. 40. *Musca domestica*, adult, "opened" and "unopened" taenidial tubes (No. 37e).   Fig. 41. *Musca domestica*, adult, showing complex taenidial fusions (No. 231b).   Fig. 42. *Phormia regina*, adult air sac, note bands suggestive of rudimentary taenidia (No. 548e).
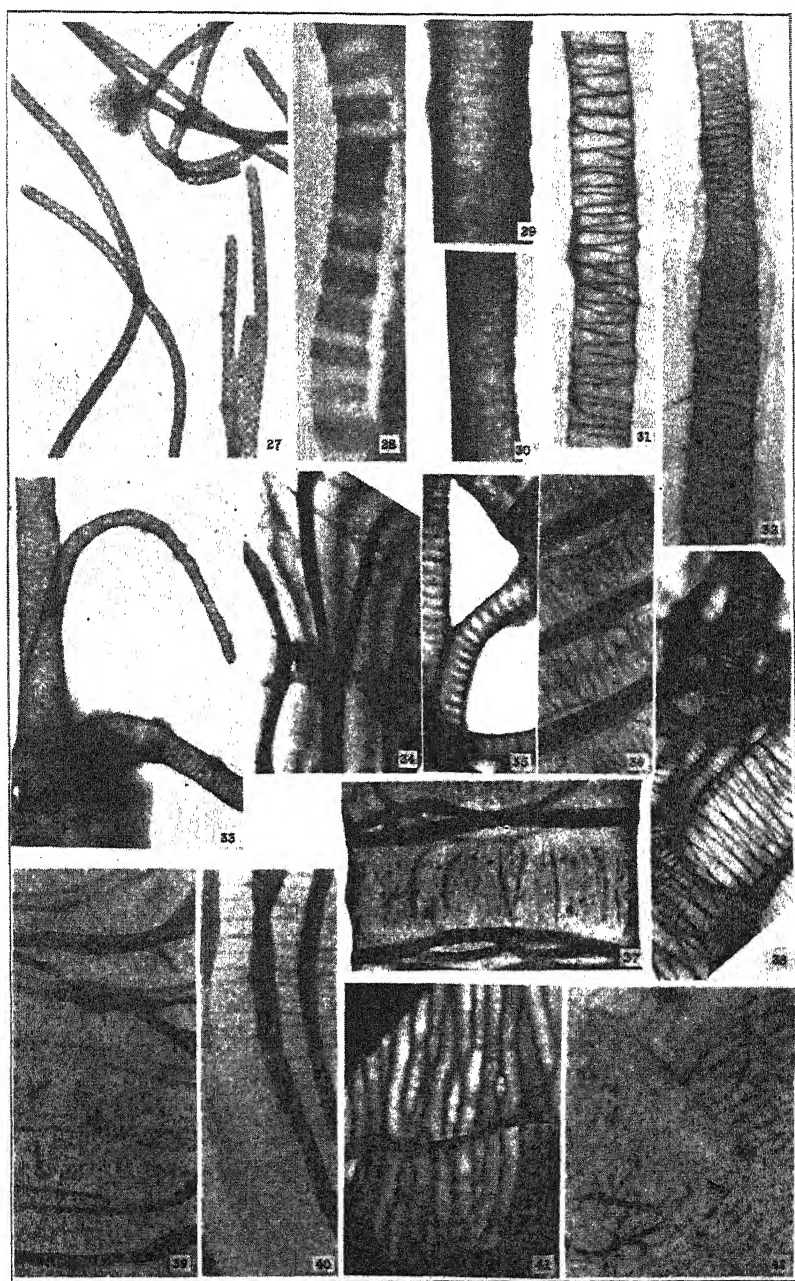
that tubular taenidia are a peculiarity of the higher Diptera rather than a developmental stage for taenidia in all groups. The strongest evidence is the fact that in other forms (*e.g.*, cockroach) the basic endocuticular membrane is continuous beneath the taenidia. More open to possible error, but nonetheless evidence, is the fact that we failed to find a tubular stage for solid taenidia. Molecular orientations in the tracheae of Diptera remain to be determined but it would seem that at least the details of taenidial origin will differ in this case even though similar stress forces may readily be conceived as producing both types.

An hypothesis of stress origin of taenidia encounters an incongruity in those species with simple or branched microtrichiae— which cannot be formed by stress forces—unless, as we think, these microtrichiae are formed around protoplasmic filaments.

Air-sac walls may show either rudimentary taenidia (flies) or no trace of taenidia (honey bee). Any hypothesis of taenidial origin could rationalize this, but it is particularly easy to postulate reduced and less oriented stresses in air-sac walls. The forces for formation of taenidia must also be poorly or only locally developed in *Scutigerella* since organized taenidia pass into regions with a relatively unorganized reticulum.

Taenidial rings as well as taenidial helices were found in almost all the species examined. Accordingly, we believe that ring-forms are quite general in occurrence, especially in tubes of small diameter. Tracheoles may have either rings or helices, and their taenidia may contrast with those of the tracheae to which they are attached. The

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EXPLANATION OF PLATE III

Preparations of tracheae from general body tissues except when specific organ is named. Figures 43, 44 and 45 at 5000 X; figures 49 and 50 at 18000 X; all others at 10000 X.

Fig. 43. *Photinus pyralis*, adult, trachea with uniform intertaenidial membrane (No. 455d). Fig. 44. *Photinus pyralis*, adult, trachea with minute lumps in intertaenidial membrane (No. 455a). Fig. 45. *Photinus pyralis*, adult, trachea with reticulated intertaenidial membrane (No. 445b). Fig. 46. *Calandra oryzae*, adult (No. 442d). Fig. 47. *Rhodnius prolixus*, adult (No. 445d). Fig. 48. *Tenebrio molitor*, adult (No. 251a). Fig. 49. *Macrodactylus subspinosus*, adult, torn area curled over showing papillae in silhouette (Anderson No. 728c). Fig. 50. *Macrodactylus subspinosus*, adult, another area of same preparation where ring-like appearance shows these lumps are really hollow papillae. Fig. 51. *Lestes* sp., adult (No. 411d). Fig. 52. *Melanoplus differentialis*, adult, prepared from partly decayed specimen (No. 561a). Fig. 53. *Reticulotermes flavipes*, adult worker (No. 263e). Fig. 54. *Eomanacanthus stramineus*, adult (No. 397b). Fig. 55. *Eomenacanthus stramineus*, adult (No. 397d). Fig. 56. *Malacosoma americana*, first instar larva (No. 377d). Fig. 57. *Macrostelus divisus*, adult (No. 236c). Fig. 58. *Argas persicus*, adult (No. 243a). Fig. 59. *Armadillidium vulgare*, adult, part of a lobe of "air tree" from abdominal pleopod (No. 733e). Fig. 60. *Scutigerella immaculata*, adult, large trachea from head (No. 303d). Fig. 61. *Theridion tepidariorum*, adult, one side of so-called trachea showing a relatively simple and therefore clearer set of pillars and cross-bars that project into lumen of this tube (No. 587e). Fig. 62. *Theridion tepidariorum*, adult, a more typical picture of one side of so-called trachea with its elaborate set of pillars and cross-bars in the lumen (No. 587a).
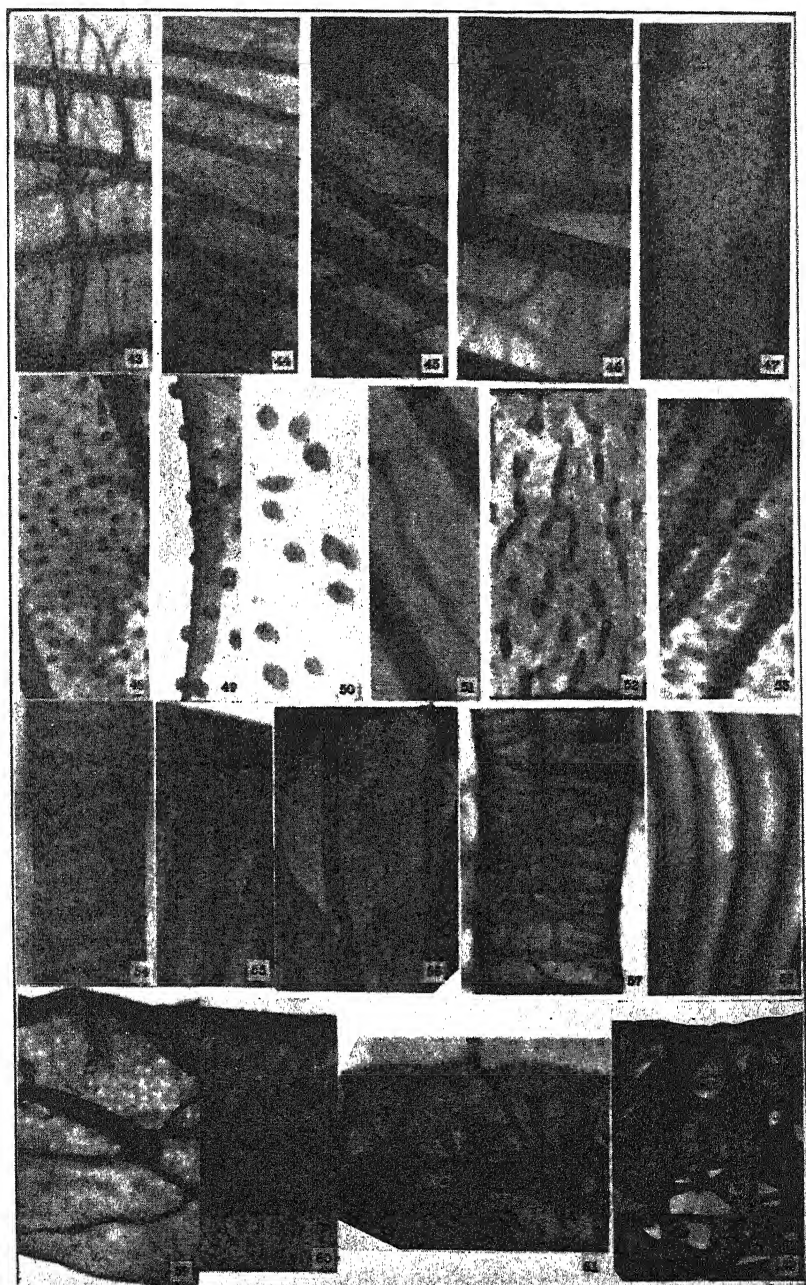
obvious postulate is that helices are developed whenever an elongational stress is added to the radial stresses we have postulated cause the observed molecular (or micellar) orientations.   This would rationalize the fact that tracheoles of some species show only rings while those of others show only helices (see plates), and, coupled with Keister's (1948) demonstration of the correctness of the view that tracheoles may arise independently of tracheae, would also rationalize finding only helices in the hundreds of *Photinus* tracheoles examined while some rings occur in the small tracheae to which the tracheoles are attached.

On any hypothesis of taenidial origin one would expect to find some taenidial fusion or branching.   In a few cases extensive fusion is seen at some points alone a trachea (fig. 41); at points where trachea branch the taenidia may form either simple (fig. 15) or complex configurations (fig. 57); with less well oriented forces (*e.g.*, air-sacs, Richards and Korda, 1948) even more fusion is seen; in the unique case of *Scutigerella* (figs. 17–19) it is only sometimes that the presumed stress is sufficiently oriented to produce a taenidia-like structure.   More branching or fusing is found than one would expect from the literature, but whatever hypothesis one favors it seems to us surprising that taenidia are as constant as they are.

<center>STRUCTURE OF THE INTERTAENIDIAL MEMBRANE</center>

The tracheal membrane is a continuous tubular sheet or, at least in larger tracheae, set of sheets which is only apparently subdivided into

TEXT FIGURE 1.   Diagrammatic sketch of a longitudinal section of a tracheal intima (based on cockroach).   Illustrates continuity of tubular membrane with taenidia superimposed, location of swellings in intertaenidial membrane in the endocuticle, and continuous epicutile which follows the contours of the surface.

short sections by taenidia.   By gentle manipulation of alkali-treated tracheae the taenidia can be removed; they uncoil from inside, giving the appearance of withdrawing a spring from a sleeve.   Also the pattern of chitin micelles in the tube wall is continuous across the taenidia (Richards and Korda, 1948).   These two points demonstrate that the basic tracheal membrane is a continuous sheet although intimately associated with the taenidia (text figure 1).   The higher Diptera with their tubular taenidia will presumably be an exception to this but must await further study.   In electron microscope pictures the taenidia are usually opaque due to their thickness; accordingly only the structure between taenidia is usually seen clearly.   In this section we will consider only the structures seen in this intertaenidial area even though the same membrane usually continues under the taenidia.

The intertaenidial membrane is a continuous sheet which is not perforated by gross canals such as gland ducts or pore canals.   It may possess a molecular sieve structure but, at least in dried membranes,

this is beyond the resolution of our pictures.   Other data (e. g., Richards and Weygandt, 1945) suggest that the permeability of tracheal membranes is of the same order of that given by dialysis membranes which likewise show no pores in electron microscopy.

The patterns shown by intertaenidial membranes can be grouped into three general types:

> (A) Membrane uniform within limits of resolution.
> (B) Membrane with linear thickenings, forming
> > (1) reticulum of thickenings,
> > (2) more or less oriented thickenings,
> > > (a) parallel to taenidia,
> > > (b) perpendicular to taenidia.
> (C) Membrane with small speckles due to
> > (1) local thickenings in the endocuticle,
> > (2) evaginations presumably over minute papillae.

Intermediates between these types are common, and all three types are sometimes found in different tracheae of a single individual (*e. g., Photinus*, figs. 43–45) although in most cases there is reasonable constancy.   The patterns may also vary from larva to pupa to adult (*e. g., Culex*, see Richards and Anderson, 1942a).   The patterns are independent of chitin since both reticulate and lump types are found with and without chitin.[4]   If desired one could add another class for those species which have microtrichia.[5]   Taking these up in order:

Intertaenidial membranes uniform within the limits of resolution are found in the tracheoles of all species examined, in the small tracheae (2–5 μ diameter) of most but not all species, and in the large tracheae of only a few species (Table II).   Commonly but not always the membrane between lumps and thickenings is similarly uniform.   A series of examples can be found ranging from strong to faint to vague to no discernible reticulum.   This might be interpreted as meaning only that the seemingly uniform membranes have a finer reticulum beyond detection in our pictures (especially since we are uncertain how much thickening is required to produce a density differentiation visible on the plates).   But this is by no means necessarily true.   The thinnest tracheal membranes are considerably less than 100 A (=0.01 μ) thick and may well be of the magnitude of 50 A thick.   Our best pictures have resolutions of this magnitude.   This is the range of sizes of the lengths of smaller protein molecules.   While the long axes of the molecules lie parallel to the surface of the membrane[6] there would still only be space for a few molecular thicknesses.   This thickness is the same magnitude as the shortest dimension of chitin micelles found in large tracheae of cockroaches [Richards and Korda, 1948).   Cuticular proteins analyzed by Fraenkel and Rudall (1947) have lattice unit spacings

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[4]See footnote 2, page 56.

[5]Marcu (1931) has presented the most complete series of types to be found in previous literature.   He recognized five groups: (1) simple with helical taenidia; (2) same but with intertaenidial thickenings parallel to taenidia (*Dytiscus*); (3) with a net-work or reticulate intertaenidial membrane (Hymenoptera and Coleoptera); (4) with thickenings perpendicular to taenidia (Buprestidae); and (5) species with hairs (microtrichia).

[6]This is actually known only for larger tracheae but may be presumed to be true for smaller tracheae and tracheoles also.

(determined from x-ray diffraction patterns) similar to those of chitin. Resolution in our best pictures is to within five to ten times these lattice unit dimensions which do not represent molecular sizes but only minimal molecular unit spacings. Accordingly, although our data do not prove it, uniform tracheal walls of the thickness of 100 A and less may well represent uniform monolayers of the wall units. Larger tracheae with thicker walls are known to consist of more than one layer but the nature of these separable layers and their relation to tracheae with thinner walls remains to be clarified.

Tracheal walls with reticulate thickenings are especially general in the Diptera but occur in a scattering of other species (Table II). Reticulate thickenings are also present in the walls of air-sacs we examined but it happens that those species from which we took air-sac walls were all ones whose tracheal walls are also reticulate. The reticulate thickenings commonly show no preferred orientations (figs. 45, 56) but in some cases (*Musca*, *Phormia*, etc.) the thickenings are definitely oriented perpendicular to the taenidia (figs. 39–42). If the uniform type of membrane is viewed as representing a uniform mono-layer, then a reticulate membrane with uniform areas between the thickenings is most readily visualized as arising from the squeezing out of excess units from such a monolayer, the pressure presumably arising from irregularities in contraction of the membrane during hardening.[7] Carrying the reasoning one step further, the excess units squeezed out could be visualized as forming a reticulum from satisfying some of the same cohesive forces that bind the units of the uniform membrane together; if units are squeezed out more or less randomly an unoriented reticulum would result, if the units are squeezed out of a highly oriented film or are placed under stress after being squeezed out they might readily become oriented ridges perpendicular to the taenidia. This series of speculations leaves out of consideration the fact that a series of reticulations is found ranging from strong (fig. 36) to weak (fig. 57) unless one wants to assume that units squeezed out may tend to aggregate with previously expelled units or may be different sizes in different species.

Two of the examples of reticulate membranes require special mention. In *Sicara*, and less distinctly in a few other species, there is a relatively weak thickening half-way between and parallel to the taenidia (fig. 34). [Marcu (1931) has recorded thickenings paralleling taenidia in *Dytiscus*.] The origin of these is not clear. In the symphylan, *Scutigerella*, the thickenings may form only a heavy reticulum or may be oriented in some areas into somewhat imperfect taenidia, as discussed in the preceding section (figs. 17–19).

The most widespread type of intertaenidial membrane is one with localized swellings or pimples (figs. 37, 47–55). In some species these become considerably elevated and project into the lumen of the tracheal tube (fig. 49). Specimens of large tracheae of the cockroach in which the epicuticle has been manually torn or the epicuticle isolated show

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[7]At least the larger reticulations cannot be produced by the drying necessary in electron microscopy because they can be seen in fresh material with a light microscope.

that these lumps are thickenings located in the endocuticle and pushing out the covering epicuticle as taenidia also do (*e. g.*, cockroach tracheae, see Richards and Korda, 1948). Presumably the same will be true for smaller tracheae which have these swellings. These lumps are usually roughly circular (fig. 48) but may be irregular (fig. 52). They may be entirely separated from one another (fig. 50), joined into ridges bracing the taenidia (cockroach, Richards and Korda, 1948), or combined with a set of reticular thickenings (honey bee, Richards and Anderson, 1942a). In a few species larger ones appear as pimples or short hollow projections which presumably represent molding around some micro-cytoplasmic projection; the clearest case of this is shown by the beetle *Macrodactylus* (fig. 50). The swellings may sometimes occur on taenidia (fig. 53). In the lice there is an unique situation; a row of lumps parallels each side of each taenidium (fig. 54–55).

The origin of these clearly defined swellings in intertaenidial membranes is not clear. All that we know is that in cockroach tracheae they are located in the endocuticle (text fig. 1) and disappear following treatments leading towards chitin purification (Richards and Korda, 1948), that in most species they are true swellings. (figs. 48, 53) but in some species they are papillae (fig. 50),[3] that their development is independent of the presence of chitin,[3] and that they appear fully formed in the intima of freshly molted cockroaches as well as in fully sclerotized dark specimens. One could suggest that they overlie equally small or smaller centers of production of the cuticular material but this would be virtually impossible to prove.

Three genera with microtrichia on the tracheal intima were examined: *Culex*, *Photinus* (fig. 43) and *Calandra* (fig. 46). These showed no differences from the ordinary types other than the presence of these usually simple filamentous processes. After treatment with hot alkali solutions the tracheae of *Calandra* retain their structure, including the reticulum in the intertaenidial membrane, but the bases of the micro-trichia become hollow. This suggests that these, like the microtrichia of centipedes (Richards and Korda, 1947), may contain protoplasmic cores. Dujardin (1849), Marcu (1929, 1931), Keilin (1944) and others have recorded branched as well as simple hairs in other species of insects. In no case have we found any setae or other forms of sensillae in the tracheal walls; all the "hairs" and "spines" are simple cuticular projections, that is, microtrichia.

<div align="center">STRUCTURE OF AIR-SAC WALLS</div>

Air-sacs have been examined in only the honey bee and three species of flies. Numerous illustrations of honey bee air-sacs have been given in previous papers (Richards and Anderson, 1942a; Richards and Korda, 1948). Honey bee air-sac walls are multilayered with irregular reticulate thickenings, most of which are true thickenings of the membrane but some (especially the larger ones) are folds or are augmented by folding. The fly air-sacs have a structure more suggestive of modified tracheae; parallel thickenings, seemingly representing rudimentary taenidia, separate strongly reticulate areas (fig. 42).

STRUCTURE OF TRACHEOLES

In all the species examined the tracheoles have been found to contain taenidia.[8] Specimens of *Peripatus* were not available but Dakin (1920) has already recorded that taenidia can be seen in fresh material. The only partial exception we have found to this generality is the symphylan, *Scutigerella;* in this case most of the tubes show unoriented reticulate thickenings while some of the smaller ones show the thickenings organized like taenidia (figs. 17–19). No tracheal tubes (or air-sacs) have been found without thickenings in the walls.[9] With the representative range of forms studied it seems reasonable to conclude that all tracheoles possess supporting thickenings which, with the partial exception noted for *Scutigerella*, are organized into taenidia.

As pointed out previously (Richards and Anderson, 1942b) it is no longer possible to say tracheoles are characterized by the absence of taenidia. The taenidia are simply beyond the limits of resolution of a light microscope. No definition based on the diameter of the tubes or on the structure of the intima seems possible. A survey of the literature suggests that no rigid definition will be possible on other grounds. In specific cases, perhaps most cases, tracheoles could be defined as those minute terminal tubes which are formed *within* tracheal cells (*e. g.*, *Sciara*, see Keister, 1948) but exceptions are known. And the fact that intracellular versus extracellular origin is no fundamental distinction was pointed out as long ago as 1889 by Schäffer and has been re-emphasized by Keister's report of both tracheae and tracheoles developing intracellularly in *Sciara* larvae. Previously we suggested that since no clear distinction could be made the term tracheole be dropped. However, it is convenient to have a name for the terminal ramifications of the tracheal system, and we propose that the term tracheole be used simply to designate the minute terminal branches of the tracheal system.

For the purpose of the present paper we have called any tube less than one micron in diameter a tracheole. This is arbitrary but we have had to make some such distinction since our preparations show us only the tracheal intima. In a few species no tubes this small were found but these were ones where a single preparation was examined, and since no blind ends were found we feel that in these few cases we simply had not obtained the smallest tubes (see Table II). The tubes which seem unquestionably tracheoles (blind endings located) occupy a narrow range of diameters: 0.2 to 0.5 μ. A number of those in which the measurement is given as 0.3 μ are clearly flattened; correcting for this such tubes would have a true diameter of approximately 0.2 μ. Flattened tubes measuring 0.5 μ (*e. g.*, *Melanoplus*) would have a diameter of approximately 0.3 μ. As pointed out in the section on methods, these measurements are not to be interpreted as more than the correct order of magnitude. But accepting the measurements as indicating

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[8]No tubes small enough to be classed as tracheoles and no side branches were found in any of the species of spiders examined though some authors say such occur (e.g., Bertkow, 1872). None of the lobes of the "air tree" of terrestrial isopods resemble tracheoles in size or shape.

[9]As noted in the section on *Methods*, cleaning with alkali solutions may cause some deterioration, including a decrease in definition or even apparent loss of the thickenings.

order of magnitude, we have to conclude that a tube with a diameter of approximately 0.2 μ is the lower limit of tracheal size and that this limit is attained in a large percentage of species. It is interesting to speculate as to why this is the lower limit. An obvious suggestion is that it represents the limit of curvature of the molecules composing the intima. Keister (1948) and some older authors have recorded that tracheole walls are formed around cytoplasmic canals. Accepting these reports, molecular forces within the wall itself might still place a lower limit on the possible tube diameter. However, if the diameter of the smallest tubes was controlled by molecular forces one would expect that the taenidia would be important and that tracheoles with helical taenidia would be significantly smaller than those with circular taenidia. This is not the case. The question seems insoluble but we feel inclined to place the probable control in the size of the cytoplasmic canal rather than in the molecules of the tracheole wall.

Allowing for variations in collapsing of the tubes, the tracheoles are usually of constant diameter for long distances (but note fig. 33). Then they terminate abruptly with a blunt or rounded tip. Anastamosis of tracheae into complex networks is common and well-known, but anastamosis of tracheoles is still debated (see Remy, 1925; Wigglesworth, 1931; Buck, 1948). Unfortunately, the nature of electron microscope preparations is not favorable for locating anastamosis unless there were complex multiple fusions or something characteristic about the point of fusion. Hundreds (more likely thousands) of free blind ends have been found on our preparations, but no preparation has been seen of a tracheole leaving a trachea and looping back to join it again. If such were common we would expect to have located some in the many preparations studied but not necessarily if they are rare or found only in special tissues, as is usually stated now. We have studied intensively one tissue where an anastamosing network of tracheoles has been reported, namely, the light organ of *Photinus* (fig. 27). We examined numerous preparations and observed literally hundreds of blind endings, many of which could be followed completely from their origin, but we found no evidence of anastamosis. With dense clusters of such tubes of dimensions at the limit of resolution of a light microscope one can readily imagine workers using a light microscope obtaining an illusion of anastamoses.[10] Numerous blind endings have also been

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[10]Dr. Buck saw some of our pictures of *Photinus*, and added a note on them in his review (1948). His facile criticisms of electron microscopy are not well founded, but more important is the fact that he questions whether the tracheoles of which we obtained pictures are the ones with which he deals. The question is not readily answered because neither his microphotographs nor our electron micrographs cover the complete picture: the microphotographs (while most excellent microphotographs) have the limited resolution of a light microscope, and the electron micrographs while having better resolution show only a tangled mass of isolated tracheae and tracheoles removed from their normal cellular surroundings. Light microphotographs give the impression that the tracheoles do anastamose in the light organ, but we must always hold the reservation that one cannot be really sure of what is actually seen when working at the extreme lower end of resolution of any microscope. Electron micrographs of tracheae and tracheoles from isolated light organs show large numbers of tracheoles which end blindly, and that these tracheoles appear to arise in sets of two, three or four. Certainly there must be something abundant in the light organ which corresponds to the structures in our pictures. Buck records that the tracheoles always arise in sets of two, and his figures show a branched trachea with two tracheoles arising

found in gill filaments of *Lestes*, *Corydalus* and *Hesperophylax*.   Considering the difficulties of flow other than diffusion through tubes a small fraction of a micron in diameter, we fail to see any material advantage that would be conferred by a tracheolar network.   However, all we can report is our failure to find such a network.

It might not be superfluous to remark that nothing resembling any form of valve structure has been seen in any of the thousands of tracheae and tracheoles observed, despite the fact that we were watching for evidence of such especially at points of bifurcation of tracheae and origin of tracheoles.

The taenidia of tracheoles may be all rings (fig. 8), or rings and helices (figs. 3, 10), or only helices (fig. 27).   In the two species of ticks examined the rings tend to occur in pairs (fig. 28).   While only small number of tracheoles were seen for most of the species it seems that the condition is characteristic for a particular species.   Whatever the nature of the origin of taenidia, it is reasonable to expect that ring forms should be more common in small tubes, as indeed they are. There is no necessary relation between the taenidia of tracheae and attached tracheoles.   In Table II, tabulation of rings and helices are for both tracheae and tracheoles combined.   For tracheoles alone (among species where reasonably large numbers were examined) only ring forms were found in *Taeniothrips*, *Rhodnius*, *Musca* and *Phormia*, while only helical forms were found in *Diapharomera*, *Pteronarcys*, *Lestes*, *Photinus*, *Tipula*, *Drosophila* and *Xenopsylla*.

With tubes both above and below one micron diameter (actual range 0.8 to 2.3μ) it is possible to find abrupt changes in taenidia with or without change in tube diameter (figs. 2, 24, 25, 32).   With a light microscope, some of these could give the appearance of abrupt cessation of the taenidia.   Such situations might originate from tracheoles growing in to connect with tracheae of the same diameter, from an extension of a trachea between moults (the part formed around a pre-existing trachea differing from the entirely new portion), perhaps from a partial shedding of the intima (Keister, 1948), or simply from an abrupt change in the forces responsible for the formation of taenidia. Locating such spots is lucky chance.   Having found them in seven species in six different orders, we suspect that they are of general occurrence (located in *Lepisma*, fig. 2; *Blatta*, fig. 25; *Diapheromera;* *Photinus;* *Apis*, fig. 32; *Aedes*, fig. 24; and *Phormia*).

Buck (1948) described a "possible ultratracheolar network" as an admittedly questionable interpretation of certain metal precipitation patterns in cells of the light organs of fireflies.   We did not recognize anything in our preparations that could be referred to the network Buck describes and figures.

As mentioned above, no resolvable detail has been seen in the intertaenidial membrane of tracheoles.   The membrane is extremely thin (<100 A when dry) and uniform within the limits of resolution.

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to the end of each twig.   One could argue, then, that sets of two in our electron micrographs represent one set, sets of four represent two sets of two, and sets of three represent a double set from which one has been torn or otherwise displaced.   However, our electron micrographs are not conclusive on this point, and we must leave the question open.   We find it difficult to believe we are not dealing with the same tracheoles Buck and other authors have described from light microscopy but we cannot prove it from our present set of pictures.

TABLE II

TABULAR PRESENTATION OF DATA OBTAINED

Arthropod	Diameter of smallest tube seen (microns)	Blind ends of tracheoles found	Ring-like taenidia seen	Helix-like taenidia seen	Intertaenidial membrane of larger tracheae
Theridion	several μ	....	no	no	Highly reticulate with rods and elevated cross-bars, no taenidia
Tetragnatha	....	....	no	no	Similar to above; see figures
Neoscona	....	....	no	no	Reticulate heavy thickenings, without elevated rods and cross bars, no taenidia
Dermacentor	0.7	....	yes	....	Relatively thick, details unclear
Argas	0.5	....	yes	yes	Taenidia not sharply demarcated, thick rings commonly double
Phalangid	0.3	....	yes	yes	Linear thickenings normal to taenidia
Pseudoscorpion	0.7	....	yes	yes	Relatively thick
Armadillidium	several μ	....	no	no	Reticulate, no taenidia, lobate rather than tubular
Scolopendra	....	....	....	yes	Relatively thick, details unclear
Lithobius	1.3	....	....	yes	Relatively thick, somewhat irregular but no definite pattern
Fontaria	1	....	yes	yes	Granulate with minute lumps
Scutigerella	0.5	yes	....	yes	Reticulations and incomplete taenidia; see figures
Lepisma	0.5	....	yes	yes	Vague reticulum
Melanoplus	0.3	yes	yes	yes	Irregular lumps with faint connecting reticulum
Ceuthophilus	3–4	....	yes	yes	Lumps (= cockroach)
Periplaneta	0.4	....	yes	yes	Lumps, seldom connected except at taenidia, figs in earlier papers
Blatta	0.3	yes	yes	yes	Lumps, tracheae less than 2μ diameter have uniform membrane without lumps
Diapheromera	0.4	....	....	yes	Lumps (= cockroach)
Pteronarcys	0.5	....	....	yes	Mostly lumps but some areas reticulate and with heavy braces
Reticulotermes	1	....	....	yes	Lumps (= cockroach)
Eomenacanthus	0.6	....	yes	yes	Row of lumps along each side of taenidia, see figure

TABLE II—(*Continued*)

Arthropod	Diameter of smallest tube seen (microns)	Blind ends of tracheoles found	Ring-like taenidia seen	Helix-like taenidia seen	Intertaenidial membrane of larger tracheae
Polyplax........	0.3	....	yes	yes	Similar to preceding but crenulated edge of taenidia less sharp
Hexagenia......	....	....	....	yes	Faint thickenings normal to taenidia
Lestes..........	0.2	yes	....	yes	Lumps (smaller than in cockroach)
Taeniothrips....	0.3	yes	yes	yes	Faint thickenings normal to taenidia
Oncopeltus......	0.4	....	yes	yes	Lumps (=cockroach)
Rhodinus........	0.3	yes	yes	yes	Lumps (=cockroach)
Macrostelus.....	0.5	....	yes	yes	Lumps (=cockroach)
Macrosiphum...	1.5	....	yes	yes	Faint reticulum, much taenidial branching
Corydalus.......	0.2	yes	yes	yes	Reticulated
Myrmelionid...	0.2	yes	yes	yes	Lumps (=cockroach)
Chrysopa.......	0.3	....	yes	yes	Lumps (=cockroach)
Bittacus........	0.3	yes	yes	yes	Lumps plus faint reticulum
Hesperophylax..	0.3	yes	....	yes	
Galleria.........	0.4	yes	yes	yes	Reticulated, some with lumps also
Malacosoma.....	0.4	....	yes	yes	Reticulated (=bee)
Carabid........	0.4	....	yes	yes	Lumps (=cockroach)
Photinus........	0.2-0.3	yes	yes	yes	Some with lumps, some with reticulum, some intermediate, also spines and braces from taenidia
Buprestid.......	0.3	yes	yes	yes	Lumpy reticulum
Tenebrio........	....	....	....	yes	Lumps (=cockroach)
Macrodactylus...	1.2	....	yes	yes	Lumps which are distinctly pimples
Scarabaeid.....	0.3	....	....	yes	Reticulate plus some lumps
Calandra........	0.4	....	yes	yes	Reticulated, spines from taenidia
Neodiprion......	....	....	....	yes	Lumps, similar to ant
Camponotus.....	0.5	yes	yes	yes	Mostly lumps but some fusion into ridges normal to taenidia
Apis...........	0.2	yes	yes	yes	Reticulated, with or without lumps, air sac reticulated, see earlier papers for figures
Sciara..........	0.3	yes	yes	yes	Uniform or faint reticulum in larva, faint reticulum in adult
Tipula..........	0.5	....	....	yes	Too thick to be clear but not uniform
Culex..........	0.5	....	yes	yes	Larva homogeneous, pupa and adult reticulate, minute spines on main longitudinal trunk taenidia

TABLE II—(*Continued*)

Arthropod	Diameter of smallest tube seen (microns)	Blind ends of tracheoles found	Ring-like taenidia seen	Helix-like taenidia seen	Intertaenidial membrane of larger tracheae
Aedes	0.3	....	yes	yes	Faint lumps and reticulum in larva, reticulum in pupa, lines normal to taenidia in adult
Drosophila	0.2	yes	yes	yes	Reticulate with tendency for lines to be normal to taenidia
Musca	0.4	....	yes	yes	Linear thickenings normal to taenidia; taenidia appear to be hollow tubes; air sacs appear to have rudimentary taenidia; see figures
Phormia	0.2	yes	yes	yes	Similar to preceding
Xenopsylla	0.4	....	yes	yes	Lumps (= cockroach)

SUMMARY

1. Tracheae and tracheoles of species representing most of the major groups of tracheate arthropods have been examined with an electron microscope. In all cases these tubes were found to contain supporting thickenings. With the exception of the lobate "air trees" of terrestrial isopods, the so-called tracheae of spiders, some (but not all) of the tubes in the symphylan, and some insectan air-sacs, the thickenings are organized into taenidial bands.

2. Taenidial rings as well as helices were found in most of the species, especially in smaller tubes. Tracheoles commonly show exclusively one or the other as a specific characteristic. Fusion and branching of taenidia is common. Taenidia are almost always solid thickenings but in some higher Diptera they are tubular.

3. Tracheal membranes between taenidia may be uniform, with reticulate thickenings which may or may not show preferred orientations, or with local swellings. The type with minute lumps is most common; these are usually swellings in the endocuticle but in some cases are thin-walled cuticle presumably over correspondingly minute papillae. These types are independent of the presence or absence of chitin, and show no constant correlation to taxonomic relationships.

4. Microtrichia are present in relatively few cases; when present most of them arise from taenidia   True setae and sensillae are absent. Gland ducts, pore canals or other gross holes were never found.

5. Nothing resembling a valve structure has been seen in the intima of any species.

6. Tracheoles contain taenidia, and cannot be identified on a basis of size or of structure of the intima. It is proposed that the term tracheole be used simply to designate the terminal branchings of the

tracheal system (irrespective of whether or not found in "tracheal end cells") without any connotation of a fundamental distinction between tracheae and tracheoles.

7. Tracheoles are of fairly constant size throughout the Arthropoda. The lower limit seems to be a tube with a diameter (when dried) of 0.2μ, and most of those seen lie in the range of 0.2 to 0.5μ. Blind, blunt, or rounded endings are common. No anastamoses of tracheoles were located.

8. The origin of tracheal membranes and of taenidia is considered. While the discussion is necessarily speculative, it is thought that available data are consistent with an hypothesis that a combination of monolayer phenomena and radial stress forces could bring about this type of tubular structure. Taenidia may be developed as either rings or helices, depending presumably on whether or not a longitudinal stress component is added to the postulated radial stress.

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THE LIFE OF WILLIAM T. DAVIS, by Mabel Abbott. Cornell University Press, Ithaca, N. Y. xv+321 pp., 26 illustrations. End paper map of Staten Island. 1949. Price $3.50.

When the writer of this review visited New York in the spring of 1922, being a coleopterist, he called on Mr. C. W. Leng at the Staten Island Institute of Arts and Sciences. In the course of the morning Mr. William T. Davis dropped in and shortly we were making our way to 146 Stuyvesant Place where on the top floor of his residence we inspected Mr. Davis' own collections, especially the cicadas. That was virtually my only contact with Mr. Davis. It was sufficient, however, so that a month or so ago, when the announcement of *The Life of William T. Davis* came to my desk, I knew at once the book was a must, and when the book arrived, I read it from cover to cover.

William T. Davis was born on Staten Island in 1862, descended on his mother's side from an old and prosperous Staten Island family. His parents were divorced when he was a boy, and he lived with his mother, grandmother, sister, and two maiden aunts! He early became absorbed in field natural history, and between the ages of 17 and 73 he kept intermittent "Natural History Notes"—seven bulky volumes of long pages written in longhand on both sides of the paper. Between 1883 and 1944 Mr. Davis published nearly 400 papers and reviews and over 150 notes, mostly on natural history topics. From 1883 to 1909 he worked in the office of the New York Produce Exchange Gratuity Fund in Manhattan. For fleeting months at the turn of the century it seemed that Davis' passion for nature might share itself with a wife, but Mrs. Davis died thirteen months after their marriage, and the beloved naturalist of Staten Island was left undisturbed with his natural history for another 43 years!

Even if it were possible, it would be superfluous to retell here the joys and sorrows, the laughter in spite of tears, of the 83 years that Mabel Abbott relates so sympathetically and so well. We see "Willie" Davis as a boy prowling the fields of Staten Island. We see him as a young man assisting in founding the Natural Science Association of Staten Island (later the Staten Island Institute of Arts and Sciences). We see him after his "retirement" in 1909 going further afield—to Florida, Virginia, and elsewhere—but always returning to the Staten Island he so loved. We see him becoming a world authority on cicadas and we experience the anticipation with which he traced the generations of Brood Two of the seventeen-year cicada on Staten Island: 1894—1911—1928. We see William T. Davis growing old in body—but never in spirit. We see him bed-ridden during his last six months—worrying about his finances even though about to leave the Staten Island Institute nearly $200,000—dying January 22, 1945, within three months of the appearance of Brood Two!

But I keep you too long from the delight of the book itself!

—Melville H. Hatch.

APPARATUS FOR THE STUDY OF POPULATION MODELS OF DROSOPHILA AND OTHER INSECTS[1]

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The present paper describes apparatus which may be found useful whenever it is desired to maintain continuous populations of certain kinds of insects over long periods of time. Specifically, the present apparatus is designed for the maintenance and handling of *Drosophila* populations, but it may, with or without modification, be used for a large variety of different forms. As is now well known, the principal
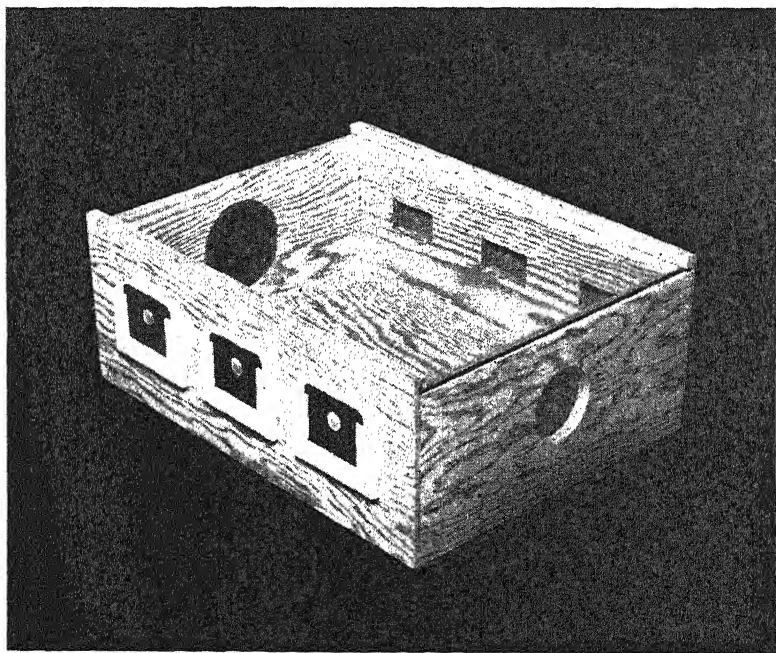
FIG. 1.   Population box.

advantage of maintaining what is called a continuous population, is that it avoids the serious sampling error which results from transferring populations from one container to another.

Two types of apparatus have been described for the maintenance of continuous populations of *Drosophila* (a third type is mentioned, but

not described, by Wright and Dobzhansky (1946)). The first of these, introduced by L'Héritier and Teissier (1933) and used subsequently in a modified form by Wright and Dobzhansky, is a box containing many small units of culture medium. Exhausted units are replaced by fresh ones at regular intervals, thus avoiding, or at least greatly reducing the sampling error introduced by changing whole populations from bottle to bottle. It is this replacement feature which makes possible the maintenance of a continuous population with minimum sampling error when a population box is used.

The second type of apparatus, devised and used by Reed and Reed (1948), is somewhat different from the first. Two bottles containing culture slants are coupled by a piece of rubber tubing. Since at regular intervals the older of the two bottles is replaced by a new one, the population alternates in using the two masses of medium. This alterna-
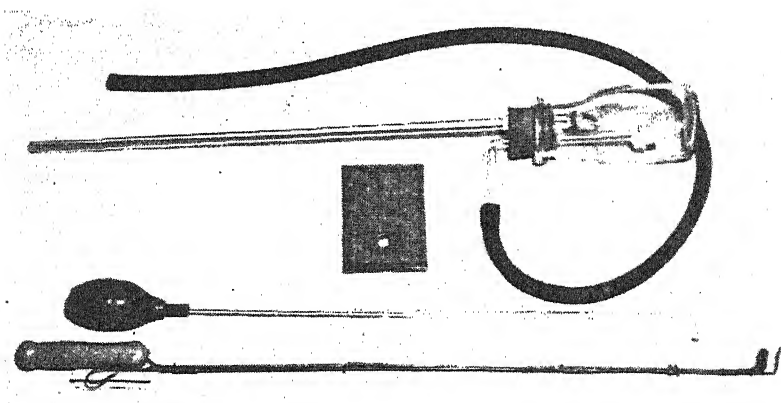
Fig. 2. Accessory apparatus: aspirator, door for use with aspirator, pipette, and forceps.

tion corresponds to the replacement feature of the population box. The authors point out that by using this apparatus it is possible to simulate a seasonal cycle with respect to food supply and population size, and that counts made while the population is at minimum are important for the detection of chance variations of gene frequency.

The box shown in fig. 1 is a further modification of the original population box, or cage. With the original type the culture dishes were introduced through holes in the bottom of the box and supported in position by corks, to which they were held by wire loops. With the type of box described in the present paper, culture dishes (Stenders, $1'' \times 2''$) are exchanged through side windows by means of a long forceps; extra food and water, if desirable, are similarly introduced by means of a long pipette. Larval samples can be taken simply by removing one or several of the culture dishes, while adult samples can be obtained by using an aspirator. Escape of flies during these operations is almost nil and can be prevented altogether by directing a fanned-out air jet

against the window being used.   The glass top can easily be replaced by a clean one while the experiment is in progress.   Screen-covered vents in the ends of the box provide ventilation.

The size of population boxes may, of course, be altered to fit the needs of different experiments.   The inside dimensions of the box shown in fig. 1 are 16 x 12 x 5 inches; since the outside dimensions of the box described by Wright and Dobzhansky (1946) are 17 x 12 x 5.5 inches, both types are of approximately the same volume.   Depending on the purpose of the experiment, it may at times be desirable to alter the ratio between space and amount of food available to a population. While this can be done with the unmodified box, it can be done more easily with a box of the present type.   Partitioning, reduction of size of culture unit and reduction of number of units are possible with both types, but increase in number of units is more feasible with the present type.   Thus by using a large number of small cultures it is possible to reduce the sampling error due to replacement still further, should it be considered desirable or necessary to do so.

The present modifications of the population box and accessory apparatus have been made primarily to increase convenience of operation and secondarily to make the box more adaptable to different kinds of experiments.   As to choice between using a population bottle or a population box, it may be pointed out that while either can be modified to handle a larger or smaller population, it seems probable that the box may be more satisfactory for the former, the bottle for the latter. If this is correct, the bottle may be more instructive for the study of the drift effect while the box, in which drift can be minimized, may be more suitable for the study of selection alone.

<div align="center">LITERATURE CITED</div>

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ON INDIAN INSECT TYPES. I. EXTERNAL AND INTERNAL ANATOMY OF THE BUFFALO-LOUSE, HAEMATOPINUS TUBERCULATUS BURMEISTER, by M. A. H. QADRI. Aligarh Muslim University Publications (Zoological Series). 21 pages, 9 plates. October, 1948. Price, Rs. 3.

According to the preface, this work is the first in a series of seven morphological studies dealing with common Indian insects of economic importance.   The editor of the series is Professor M. B. Mirza of Aligarh Muslim University.

Dr. Qadri's study deals more with internal than with external anatomy, the latter, except for a consideration of the mouth parts, being given but little more than two pages in the text.   The thorough study of the mouth parts has resulted in some important new concepts, particularly in relation to the feeding process. An extensive study is made of the internal digestive organs and of the musculature. The other systems are treated more briefly.

The illustrations appear to be adequate and functional, and they are printed on a good grade of plate paper.   The paper of the text is of good quality, though somewhat thin.   The work is well-written, in a clear style.—M. T. J.

A REVIEW OF THE SPECIES OF CULEX OF THE SUBGENUS MELANOCONION

(Diptera, Culicidae)[1]

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INTRODUCTION

Few, if any, groups of mosquitoes present greater taxonomic confusion and difficulty than does the subgenus *Melanoconion*. At the present time, the species can be recognized with certainty only by the structures of the male terminalia. The females of most species can not be separated from one another; they are usually small and dark-colored, only a few having a distinctive golden-scaled scutum or white-ringed tarsi. The larvae of many species are readily recognizable, but for the most part they are insufficiently known to permit positive identification.

The confusion that exists in this group is attributable in part to the difficulty with which the characteristic structures of the terminalia can be made out in the very poor whole mounts of the type specimens made by the earlier workers; in part by the lack of appreciation among present day as well as by the older taxonomists of the necessity for properly mounted terminalia; and in part by the reliance on the inadequate literature by workers without access to the type material for the identification of their specimens. Many culicidologists have fallen, and no doubt others will fall into the error of describing as new, specimens which do not conform to Dyar's (1928) misleading descriptions, keys and figures. It is essential for proper description that the details of the form and position of the appendages of the lobes of the sidepiece be described and figured accurately. One common error seen in the earlier literature is the failure to note the presence of a distinct leaf among the filaments of the outer division of the lobe of the sidepiece. This leaf is difficult to see in preparations of the terminalia which have been macerated and cleared too thoroughly. Light staining of the parts increases their visibility greatly. Another obstacle to species identification is an inaccurate description of the lateral aspect of the inner plate

of the mesosome, which is one of the most useful structures for determination. In many groups of mosquitoes, and even in some species of *Culex*, such as *C. pipiens* and *C. quinquefasciatus*, splitting the mesosome apart is unnecessary for, or even detrimental to, accurate identification. But in the species of *Melanoconion*, dissection and mounting of the inner plate of the mesosome in lateral aspect is absolutely essential to proper description. Vague references to the mesosome as being "cup-shaped furcate," and the like, are valueless. Even in those species with distinctive or bizarre specific characters the lobes of the sidepiece and the mesosome should be completely described in order that they may be properly placed in an adequate key. Prospective students of this group of mosquitoes are urged to consider seriously the recommendations made by the junior author (1942) concerning techniques for mounting the male terminalia.

We cannot refrain from disparaging the use of any of the many modifications of water-soluble chloral-gum arabic media (Berlese, Gater, de Faure, Langeron) for "permanent" mounts of the male terminalia. In our experience, particularly in the tropics, none of these various types of media have proved permanent. After several years the solvent water evaporates, even though the cover-glass has been ringed with a sealing agent, and the medium becomes brown and granular, or contains large air-spaces, often completely obscuring the parts mounted therein. For confirmation of these statements, we refer to the slide of the male terminalia of the type of *Anopheles* (*S.*) *thomasi* Shannon, 1931 (syn. *lewisi* Shannon, 1931) made in 1930, and the slide of the male terminalia of one of the type series of *Culex* (*M.*) *inhibitator* D. and K., 1906, mounted in 1936. The first slide, after 18 years (1948), is almost completely indecipherable, and the second slide, now (1948) shows large air-spaces under the coverslip, after only 12 years.

The use of polyvinyl alcohol, as advocated by Downs (1943), has not proved to be successful, as the junior author examined many terminalia mounted in this medium by this author, and found that in slides five years old the results were extremely variable, some mounts being excellent, and others almost indecipherable. The need is great for a really permanent water-soluble mounting medium, which will avoid the necessity for dehydration, clearing, and mounting in balsam (or its equivalent), but which to date is the only method which assures permanent mounts. Some of Root's slides of male terminalia, mounted in balsam in 1927, are apparently in almost as good condition after 21 years, as when first made.

The Bonnes (1925) state: "As a rule we think it would be better not to describe new species on hypopygial characters alone unless very distinct, and one should always try first to get the corresponding larvae. . . . It occurs however that larvae and adults do not show differences with related species while the hypopygium is distinct." Their advice is still good, but both of us have not hesitated to describe new species of *Melanoconion* from only a single male terminalia, for with an adequate technique it is entirely possible to make mounts which display all the parts of the terminalia, so that their forms and relationships can be made out. Most of the slide mounts of the Bonnes' types are very poor, and some are nearly indecipherable, as they lacked a good technique.

This has detracted greatly from the value of their pioneer work in South America.

The purpose of this paper is to present the results of a comparative study of the morphology of the male terminalia of the species of *Melanoconion*, and the consequent revision of some of the synonomy in accordance with the information obtained during our study. We worked primarily with the type specimens of the species in the United States National Museum, supplemented by extensive material collected by us in the American tropics. Many of our illustrations were made from dissected specimens in our collections, which were positively identified by comparison with the types. No reliance was placed on published descriptions, so far as possible. Unfortunately, a few species of the subgenus are not represented in the United States National Museum collection, and these had to be described and placed in our key from the often inadequate descriptions available.

Classification.—The *Melanoconion* species are small dark mosquitoes, of strictly neotropical and nearctic distribution. They are characterized as follows: male palpi longer than those of the female, and at least half the length of the proboscis; tenth sternites (paraprocts) of the male terminalia ending in a comb-like row of teeth; inner plates of the mesosome with curved "basal hooks," but without a recurved hook on the plate as in *Microculex*. These species have been classified quite differently by Dyar and by Edwards. The latter (1932) rejected Dyar's several subgenera, which were based mainly on the shape of the male clasper (style). Edwards arranged the many species in three groups on external characters only, but we believe that this grouping is artificial and erroneous, as many entirely unrelated species are thus placed together, such as in Edwards' Group A, *mychonde* and *taeniopus:* in his Group B, *chrysonotum* and *commevynensis:* and in his Group C, such widely diverse forms as *aikenii* and *egcymon*. Although Dyar's subgeneric grouping is not altogether satisfactory, we think it gives a more nearly accurate picture of the relationships within the subgenus. Dyar (1928) divided the species into two subgenera, *Mochlostyrax* and *Melanoconion*. The first he further subdivided into "sections," such as *Dinoporpa*, *Helcoporpa*, *Mochlostyrax*, and *Choeroporpa*; and the second into sections *Tinolestes*, *Gnophodeomyia*, *Melanoconion* and *Anoedioporpa*. All these sections are based on the form of the male clasper. We have followed Dyar's classification with one exception, in that we call the whole subgenus, as characterized above, *Melanoconion* (Theobald, 1903) as Edwards (1932) does, but retain Dyar's sections as here listed. We have here mentioned all the species included in these sections with the exception of the four valid and one doubtful species placed by Dyar in section *Anoedioporpa*, and the single species *americanus* Neveu-Lemaire 1902 (=*antillum-magnorum* Dyar 1928), which Edwards (1932) transferred to subgenus *Micraedes* Coq. 1905.

KEY TO THE SPECIES OF THE SUBGENUS MELANOCONION

The separations made in this key are based primarily on the following structures of the terminalia: the shape of the clasper; the shape of the inner plate of the mesosome; the shape of the lobes of the ninth tergites; and the form and arrangement of the filaments and leaves on the outer

division of the lobe of the sidepiece. The key might have been constructed in such a way that any one of these characters might have been given primary place, but we have followed to a large extent the original separation made by Dyar, based on the shape of the clasper.

A difficulty arises in the use of this key, in couplet 12, "Outer division of lobe of sidepiece with a leaf," and its opposite. Sometimes the leaf, although present, is difficult to see, because of its orientation. If viewed edge on, it may appear as a filament. In using this key, it is suggested that, if the specimen does not key out among the species noted as "with a leaf," it be run through again, using the alternative, "without a leaf." The same situation applies to the couplets dealing with the shape of the mesosome, which is often difficult to discern in undissected terminalia. If the identification cannot be made by using one method of separation, it is well to try another character on which separation is based, and thus exhaust the possibilities. It is hoped that the figures will assist in identifying the species, when used in connection with the characters given in the key.

1. Clasper simple, without special modifications (fig. 26). Section *Melano-conion*... 2
   Clasper with the distal portion divided, expanded, or snout-shaped........ 8
2. Clasper thick, evenly broad to about one-fifth the distance from the tip, then tapering to a point (fig. 2)....................................... 3
   Clasper slender, tapering rather evenly from base to tip (figs. 4, 26)........ 4
3. Lobe of sidepiece short, stout; a patch of setae below it; inner division with two short, stout, truncate-tipped rods and a third pointed rod; outer division reduced to a prominence with one long, slender seta and several smaller ones (fig. 46). Section *Tinolestes*.............latisquama
   Inner and outer divisions of lobe widely separated; inner division long, columnar, with two stout rods at apex; outer division long, columnar, with a long stout curved filament at tip; a stemmed, expanded, striate leaf near base of column; a broad filamentous leaflike seta on sidepiece distal to outer division (fig. 2). Section *Gnophodeomyia*............aikenii
4. Sidepiece with a distinct striate leaf distal to outer division of lobe........ 5
   Sidepiece without a leaf in this position; outer division of lobe sessile, with a triangular leaf and expanded, hooked filament; inner division columnar, with an apical rod and one at base of column; one to six or more broad, curved filaments on sidepiece above and at the same level as inner division; lobes of ninth tergite pear-shaped, the outer angle much produced and pointed (fig. 9)...atratus
5. Lobes of sidepiece distinct, the outer division long, columnar; the leaf distal to outer division long, striate................................. 6
   Lobes of sidepiece sessile, the outer division with a stemmed, expanded, striate leaf and a seta; inner division with three long and one shorter filaments, the latter flattened (fig. 78)..........................spissipes[2]
6. Inner plate of mesosome smooth on dorsal margin....................... 7
   Inner plate of mesosome spicular on dorsal margin; outer division of lobe of sidepiece with an expanded, striate leaf inserted below apex; and four or five widely spread setae, one with hooked tip, at apex; inner division of lobe with one long, stout, and two more slender filaments (fig. 26)....dunni
7. Inner division of lobe of sidepiece with two stout, semicylindrical filaments, one from apex and the other from the column below; a third much smaller, setiform filament more basad on column (fig. 91)................zeteki[3]
   Inner division of lobe of sidepiece with a single stout filament and a seta at base (fig. 19)..commevynensis
8. Clasper with three erect arms at apex (fig. 86). Section *Dinoporpa*...trifidus
   Clasper unbranched.. 9

[2]See discussion of this species in alphabetical list of species.
[3]See alphabetical list for emended spelling.

9. Clasper widened and obliquely excavated at tip; a large revolute leaf on
    outer division of lobe of sidepiece (fig. 52). Section *Tielcoporpa*....menytes
    Clasper widened beyond middle, then tapering to apex, forming a snout-
    shaped tip; or with apex roundly expanded; or with apex foot-shaped in
    outline..10
10. Clasper with distal portion widened proximally, then narrowed to an
    upturned, truncate, snout-shaped tip (figs. 1, 3, 4); or snout greatly
    attenuated (fig. 31).   Section *Choeroporpa*............................11
    Clasper with slender stem, the distal third abruptly and roundly expanded
    (fig. 66); or the distal third of clasper roundly tapering to its tip, foot-
    shaped in outline, without an upturned truncate snout at tip (fig. 5);
    inner plate of mesosome (except in *rooti* and *unicornis*) of characteristic
    shape, with a narrow stem above a sharp ventro-basal horn, and termi-
    nating in three sharp, radiating points (figs. 5, 16, 66, 88). Section
    Mochlostyrax...80
11. Inner division of lobe of sidepiece divided, the filaments divaricate (figs.
    3, 4, 28, 34, 55); or this division cleft to base, with the filaments more or
    less parallel (fig. 10); or with the lower arm arising as a short offset near
    middle of column (fig. 1)...12
    Inner division of lobe not divided, arising as a long column; the filaments
    close together and usually parallel, not separated all the way to their
    bases (figs. 12, 89, 22)...13
12. Outer division of lobe of sidepiece with a leaf.............................14
    Outer division of lobe of sidepiece without a leaf.........................44
13. Outer division of lobe of sidepiece with a leaf.............................58
    Outer division of lobe without a leaf......................................73
14. Clasper very broad, somewhat narrowed before middle, sharply angled at
    middle; distal half quadrately widened, the apex with an upturned point;
    upper margin hirsute; a crest of modified setae or spines distal to hirsute
    area...15
    Clasper otherwise, the apical portion more gradually tapered, and without
    a crest...17
15. Crest of clasper composed of thickened spines..............................16
    Crest of clasper composed of fine hairs (fig. 8).........................**anips**
16. Sidepiece with a patch of fine hairs on the inner surface; crest of clasper
    broader, the spines somewhat separated; lower angle of apex of clasper
    produced downward into an acute angle; outer division of lobe of side-
    piece with a long broad leaf and three widely separated filaments
    (fig. 63)...**peccator**
    Sidepiece with scattered large hairs; crest of clasper composed of spines
    fused into a solid horn; lower angle of apex of clasper rounded; outer
    division of lobe with a large distorted leaf and four or five filaments
    (fig. 1)...**abominator**
17. Inner plate of mesosome with a broad upper arm, serrate or denticulate
    along upper margin; or serrate along edge of a laterally curved fold; or at
    least with two or three separated teeth near the dorsal angle.............18
    Inner plate of mesosome ending in two or three points, the margin of the
    plate between these points concave; or this plate like an inverted L,
    the upper arm of the L terminating in two subequal points; the upper
    point sometimes with several closely spaced denticles......................28
18. Inner plate of mesosome with a single long subapical point, in addition to
    the rounded denticulate upper arm...19
    Inner plate with two subapical points or arms...............................20
19. Clasper with a deep, parallel-sided transverse sulcus on dorsal curvature at
    middle; outer division of lobe of sidepiece with a leaf and two stout
    flattened filaments (fig. 49)..**madininensis**
    Clasper normal, without sulcus; outer division of lobe with a lower arm
    bearing the usual hook-tipped filament and the shorter lanceolate fila-
    ment; upper arm with a leaf and four slender filaments (fig. 32)....**elevator**
20. Lobe of ninth tergite with an outer conical projection; a group of setae at
    apex and along inner slope of this projection, and another group of setae
    along the rounded inner margin; outer division of lobe of sidepiece with a
    long, obovate, striate leaf inserted at extreme base; clasper greatly
    dilated beyond middle into a prominent hump, tapering abruptly from
    the hump to tip (fig. 53)..**mulrennani**

34. Outer division of lobe of sidepiece with an upper group of filaments inserted
     at the apex of a short but distinct arm (fig. 64)...............**phlabistus**
     Outer filaments not inserted on an arm.....................................35
35. Hook-tipped filament of inner arm of outer division of lobe markedly dilated
     basally; two large middle filaments present; inner division of lobe of side-
     piece with arms stout, appressed, the rods short and stout (fig. 75),
                                                                    rorotaensis
     Hook-tipped filament normal; only one middle filament between the inner
     hook-tipped filament and the outer group of appressed filaments; inner
     division of lobe with arms more slender, divaricate; the rods long and
     slender..36
36. Lobes of ninth tergite triangular in outline, the upper outer angle produced,
     bare; some long setae at base and middle of lobe; a group of dense setae
     from closely-packed tubercles at inner basal angle; inner division of lobe
     of sidepiece with arms very widely divaricate (fig. 20)........**comminutor**
     Lobes of ninth tergite ovate, or elliptical in outline; inner division of lobe
     of sidepiece with arms not so markedly divaricate.........................37
37. Lobes of ninth tergite somewhat crescent-shaped in outline, with the apex
     shortly produced upward and inward (fig. 25)...............**distinguendus**
     Lobes of ninth tergite without these upward-curving projections..........38
38. Outer division of lobe of sidepiece with a large broad leaf, inserted with the
     outer group of filaments; mesosome with the two arms of the inverted L
     about equal, the margin of the plate between the median and upper
     points convexly rounded (fig. 34)...............................**erraticus**
     Outer division of lobe of sidepiece with a narrow leaf, inserted nearer the
     middle filament; margin of the mesosome between the median and upper
     points concave..39
39. Distance between the median point of the mesosome and the origin of the
     basal hook distinctly less than the distance between the median point
     and the apex of the upper point; margin of the plate between the median
     point and the apex less concave, almost straight; the median point
     short (fig. 17); (anterior half of scutum conspicuously golden-scaled)
                                                                    chrysonotum
     Distance between the median point of the mesosome and the origin of the
     basal hook about the same as the distance between the median point
     and the apex of the upper point; margin between the median point and
     the tip strongly concave; the median point represented by a long curved
     horn; upper terminal point with several closely-appressed lamellae
     (figs. 83 and 29)................................**theobaldi, educator**[4]
40. Lobes of ninth tergite elongate-elliptical in outline, with a long tongue-like
     basal projection, usually bare; upper arm of mesosome broader than long;
     inner division of lobe of sidepiece with arms split from base, but closely
     appressed and parallel (fig. 10)..............................**bastagarius**
     Lobes of ninth tergite subquadrate or ovate in outline, without a long basal
     projection; upper arm of mesosome as long or longer than wide.........41
41. Outer division of lobe of sidepiece divided into three arms, the inner arm
     bearing the usual long hook-tipped and short filaments; the middle
     filament and a large leaf situated basally on a large tubercle; outer arm
     with three or four broad filaments; arms of inner division of lobe not
     divaricate, but divided to base (fig. 73).....................**rabanicolus**
     Outer division of lobe of sidepiece not divided into three distinct arms;
     the leaf inserted near the middle filament from a small tubercle; arms
     of inner division of lobe divaricate......................................42
42. Outer division of lobe of sidepiece long-columnar; at its apex an inner
     hooked filament and a broad, distorted, striate leaf, near which are
     inserted two median filaments; and an outer group of three closely
     appressed filaments, which may appear as a single truncate filament; the
     filaments relatively short (fig. 28)................................**eastor**
     Outer division of lobe of sidepiece shorter, the filaments large, longer than
     the column, being the usual long hook-tipped and short curved filaments

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[4]The terminalia of these two species are practically identical. The adults
may be separated by the coloration of the scutum; in *theobaldi* the anterior half
is conspicuously golden-scaled; in *educator* it is unicolorous.

Outer division of lobe with only the usual single slender setaform filament
  between the middle filament and the inner hook-tipped filament; a
  long, broad filament inserted about midway on the column of the outer
  division (fig. 72).....................................**quadrifoliatus**

57. Lobes of ninth tergite with the inner angle produced upward into a small
  point (fig. 33)...**equinoxialis**
  Lobes of ninth tergite with the outer upper angle roundly produced; this
  outer portion without setae (fig. 7)............................**andricus**

58. Mesosome simple, tapering from base to apex, and ending in a single point,
  without a point or arm on the stem (figs. 52, 59)........................59
  Mesosome furcate at apex, or with either a subapical point, or a point or
  arm on the stem; or T-shaped (figs. 12, 13, 15, 89)......................62

59. Mesosome with apex curved into a beaklike hook; outer division of lobe of
  sidepiece with the outer group of filaments and the leaf from the apex of a
  long arm; the outer rod of inner division of lobe with an expanded mem-
  brane at base; lobes of ninth tergite thumb-shaped, rounded at apex;
  (scutum of adult without a dark spot before wing-base) (fig. 62)..**paracrybda**
  Mesosome tapering evenly to a point; outer group of filaments of the outer
  division of the lobe not from a long arm; the upper rod of inner division
  without an expanded membrane; lobes of ninth tergite short, triangular
  in outline, or moundlike; (scutum of adult with a large black spot before
  wing-base)...60

60. Outer division of lobe of sidepiece with an inner arm bearing three filaments;
  no middle filament; a small leaf inserted about midway on the stem of
  the outer division of lobe (fig. 58)..........................**nigrimacula**
  Outer division of lobe of sidepiece with inner arm bearing the usual long,
  hook-tipped filament and short curved filament; middle filament
  present..61

61. Outer division of lobe of sidepiece with a narrow leaf inserted at outer
  angle; the short curved filaments accompanying the hook-tipped filament
  of the inner arm of the outer division of lobe broad; outer curvature
  of sidepiece without a dense patch of long, fine setae; lobes of ninth
  tergite rounded; outer division of lobe of sidepiece with a seta near
  base (fig. 59)..**ocellatus**
  Outer division of lobe of sidepiece with a broad, striate leaf, inserted in a
  large tubercle basal to the other filaments of the lobe; the short curved
  filament accompanying the hook-tipped filament of the inner arm of
  the outer division slender, seta-like; outer curvature of sidepiece with
  a dense patch of long, fine setae; lobes of ninth tergite conical; outer
  division of lobe of sidepiece without a seta at base (fig. 70)..**punctiscapularis**

62. Mesosome with a simple, digitiform upper arm and a single point or arm
  about midway on the stem (figs. 13, 15)..................................63
  Mesosome furcate at apex; or with a short upper arm and two subapical
  points; or T-shaped..65

63. Clasper with a triangular, membranous dorsal expansion at middle; leaf of
  outer division of lobe with a heavy lower supporting arm; lobes of ninth
  tergite conical, clothed evenly with long hairs (fig. 68)............**portesi**
  Clasper without a membranous expansion at middle; leaf without lower
  supporting arm; lobes of ninth tergite low, mound-like..................64

64. Snout of clasper strongly humped, excavated beneath, with deep lamellae;
  outer division of lobe of sidepiece with a very large leaf, mushroom-
  shaped in outline; inner hook-tipped filament greatly dilated, the associ-
  ated seta enlarged and inserted in a separate arm; middle filament and
  outer group of filaments on separate arms; lobes of ninth tergite very
  small, each with about a dozen long hairs; median point of mesosome
  short (fig. 15)...**cauchensis**
  Snout of clasper not strongly humped and without deep lamellae; outer
  division of lobe of sidepiece with a narrow leaf; inner hook-tipped filament
  not enlarged; inner division of lobe with a long stout spine from the
  base below; lobes of ninth tergite longer, the hairs shorter; mesosome
  with a long, curved, median arm (fig. 13)....................**breviculus**

65. Mesosome T-shaped; clasper with a dorsal membranous expansion at
  middle; leaf of outer division of lobe of sidepiece with a thick, sclerotized
  lower arm, from which the membranous dorsal portion arises (fig. 89),
  vomerifer

Mesosome furcate, or with an upper arm and two subapical points; clasper
without a dorsal expansion; leaf of outer division of lobe without a
heavy lower supporting arm..66

66. Leaf of outer division of lobe of sidepiece at apex of a very long upper arm;
clasper with a dense group of fine setae on under side at middle third
(fig. 22)..**coppenamensis**
Leaf of outer division of lobe not at apex of a long upper arm; clasper with-
out setae on inner curvature..67

67. Inner division of lobe of sidepiece with outer arm greatly expanded at
apex; a membrane extending from this expanded portion to the inserted
rod; outer division of lobe with an outer group of three broad sinuate
filaments, inserted at apex of a distinct arm; lobes of ninth tergite ovoid,
with slender setae scattered evenly over upper three-fourths (fig. 71),
putumayensis
Inner division of lobe with arms normal, not expanded, and without the
membrane extending to the rods.....................................68

68. Clasper broad distally, and narrowing abruptly to apex; head of clasper
with fine striations near the lower seta (fig. 85)................**tournieri**
Snout of clasper narrowly tapering to apex; head without such striations....69

69. Clasper with a triangular flaplike membrane on the inner surface before
the apex; outer division of lobe of sidepiece without the usual group of
appressed outer filaments, but with four subequal, evenly spaced filaments
above the inner hook-tipped filament; lobes of ninth tergite triangular in
outline, with long slender hairs scattered evenly over the surface
(fig. 12)...**bequaerti**
Clasper without a membranous expansion; outer division of lobe of side-
piece with the usual group of three or four closely appressed outer fila-
ments; lobes of ninth tergite not as above............................70

70. Snout of clasper smooth, without the usual lamellae or small spines on
upper surface; median point of mesosome a long, curved arm; upper
point with several closely appressed lamellae..........................71
Snout of clasper with small spines on upper surface; median point of meso-
some small; upper point without lamellae..............................72

71. Lobes of ninth tergite subquadrate; outer division of lobe of sidepiece with
outer group of filaments not inserted on an arm; lower rod of inner
division of lobe inserted basad of the upper rod (fig. 39)........**implicatus**
Lobes of ninth tergite subquadrate, but with the outer upper angle pro-
duced, bare; outer division of lobe of sidepiece with outer group of fila-
ments from a short arm; upper rod of inner division of lobe inserted
basad of the lower rod (fig. 40)..........................**inadmirabilis**

72. Outer division of lobe of sidepiece long, columnar, bearing an apically
expanded leaf; the filaments relatively short, shorter or about the length
of the column; a long seta at middle of column; the small filament associ-
ated with the inner hook-tipped filament short and curved (fig. 57),
nigrescens
Outer division of lobe of sidepiece short, shorter than the filaments, with a
distinct inner arm bearing the usual hook-tipped filament; the seta
associated with this long and slender; leaf long, elliptical (fig. 84)...**thomasi**

73. Lobes of ninth tergite large, the outer half of the lobe elbowed upward; the
apex expanded and clothed with very long, erect hairs; upper arm of
mesosome serrate on upper margin....................................74
Lobes of ninth tergite smaller, digitiform, elliptical, ovoid, or conical;
mesosome without serrations..75

74. Snout of clasper very long, half the length of the clasper, with a terminal
appendicle; upper arm of mesosome quadrate, the serrations even and
numerous; inner division of lobe of side-piece long, columnar (fig. 30),
egcymon
Snout of clasper greatly attenuated and tapering evenly to a slender,
pointed tip, without terminal appendicle; upper arm of mesosome nar-
rowed to dorsal margin, the serrations few and irregular; inner division
of lobe of sidepiece and the two inserted rods short and stout (fig. 31),
elephas

75. Mesosome T-shaped...76
Mesosome furcate at apex, or with a upper arm and two subapical points;
or L shaped, with a third point at the angle............................77

76. Clasper roundly humped dorsally before the snout, upper margin with long
    hairs, forming a small crest behind the hump; a fanshaped, stemmed leaf
    on sidepiece distal to the outer division of lobe; upper rod of inner division
    of lobe of sidepiece without a membranous expansion; apex of sidepiece
    with many long setae from sclerotized tubercles; lobes of ninth tergite
    digitiform, the setae directed basad (fig. 45)....................**jubifer**
    Clasper without hump, the upper margin of snout with small spines; side-
    piece without leaf; upper rod of inner division of lobe of sidepiece with
    a membranous expansion; lobes of ninth tergite small, conical (fig. 80),
    taeniopus, crybda
77. Clasper with a "beard" of long hairs from tubercles on under side
    (fig. 18)..**comatus**
    Clasper without this structure..78
78. Lobes of ninth tergite digitiform, wrinkled; inner division of lobe of side-
    piece with lower rod expanded at middle; mesosome with two small,
    rounded, subapical points; the upper arm above these points broad, the
    dorsal margin scarcely concave (fig. 61)......................**opisthopus**
    Lobes of ninth tergite elliptical in outline; inner division of lobe of sidepiece
    with lower rod normal; mesosome furcate, the third median or ventral
    subapical point long and sharp-pointed....................................79
79. Snout of clasper evenly tapering to tip, with deep lamellae on upper margin;
    inner division of lobe of sidepiece with several sharp creases at apex
    before insertion of rods; middle filament of outer division of lobe long
    and not swollen; mesosome bent at middle into an inverted L, the median
    point at the angle (fig. 69)..................................**psatharus**
    Clasper humped before snout, with small hairs on upper margin of snout;
    inner division of lobe of sidepiece normal, without creases at apex; middle
    filament of outer division of lobe widely expanded, three or four widened
    appressed filaments above this; mesosome erect, with a narrow pointed
    upper arm and two subapical points; hook-tipped filament arising abnor-
    mally near base of outer division of lobe (fig. 90).................**ybarmis**
80. Lobes of ninth tergite large, the outer upper angle produced upward, and
    clothed with long hairs; terminal expansion of clasper foot-shaped in
    outline...81
    Lobes of ninth tergite smaller, digitiform; terminal expansion of clasper
    rounded in outline; sidepiece with a dense patch of fine hairs on outer
    curvature..84
81. Upper ventral point of mesosome much longer than the apical and subapical
    dorsal points; lobes of ninth tergite large, constricted at middle; inner
    dorsal projection triangular, hyaline; the terminal portion almost globular,
    with long hairs (fig. 16).....................................**caudelli**
    Upper ventral point of mesosome about equal to two dorsal points; lobes of
    ninth tergite constricted at middle, but terminal portion not globular.....82
82. A large obovate leaf on outer division of lobe of sidepiece proximal to
    insertion of the long, hook-tipped filament; lobes of ninth tergite large,
    constricted at middle, the inner dorsal margin with a long, spatulate,
    hyaline projection, nearly as long as the outer hairy portion (fig. 54),
    species A[6]
    Leaf absent in this position..83
83. Lobes of ninth tergite with inner dorsal hyaline projection nearly as long as
    outer hairy portion; a long striate leaf inserted equally with the filaments
    of the outer arm of outer division of the lobe of the sidepiece; inner
    division of lobe of sidepiece with lower arm short (fig. 5).........**alogistus**
    Lobes of ninth tergite with inner dorsal hyaline projection very short; outer
    division of lobe of sidepiece without a leaf among the filaments; inner
    division of lobe of sidepiece with lower arm nearly as long as upper
    arm (fig. 88)...**vexillifer**
84. Sidepiece with one or more long, spatulate filaments near the inner division
    of the lobe...85
    Sidepiece without such filaments..87
85. Mesosome of typical *Mochlostyrax* structure, with three short sharp apical
    points; sidepiece with one to three clubshaped filaments situated below

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[6]See discussion of this species in alphabetical list.

ALPHABETICAL LIST OF THE SPECIES OF THE SUBGENUS
MELANOCONION THEOBALD[7]

We do not give a complete synonymy. For this the reader is referred to Edwards (1932), Komp (1935), Lane (1939), and King and Bradley (1937). The changes in synonymy resulting from the present study are noted. It is, unfortunately, also necessary to synonymize several names that have appeared subsequent to Lane's catalogue (1939). The figure numbers correspond with the numbers in the following list.

1. **abominator** Dyar and Knab, 1909. Smiths. Misc. Colls., Quart. Iss. 52: 257. Plano, Texas, U.S.A. Nearctic. See King & Bradley for revalidation of this species, earlier known as *erraticus* D. & K., 1905, in part.

2. **aikenii** (Aiken), 1906 (*Gnophodeomyia*). Brit. Guiana Med. Annual 1906, 60. New Amsterdam, British Guiana.

3. **albinensis** Bonne-Wepster and Bonne, 1920. Ins. Ins. Mens. 7: 173. Parimaribo, Surinam. *C. gordoni* Evans, 1924, may be this species, but her figure of the lobes of the ninth tergite is unlike those of *albinensis*, and the latter has more filaments on the outer division of the lobe of the sidepiece than are shown for *gordoni*. The Bonnes' figure 43 (1925) of *albinensis* conveys no idea of the actual appearance of the terminalia of the type male, nor does that of Dyar (1928, fig. 259).

4. **alcocci** Bonne-Wepster and Bonne, 1920. Ins. Ins. Mens. 7: 171. Zanderij, Surinam. This species is readily recognized by the long, ribbonlike, striate filament arising from the base of the outer division of the lobe of the sidepiece, and by the fine, hairlike tips of the comb-like teeth of the 10th sternites. The mount of the terminalia of the type male is in unusually poor condition, even for an early Bonne slide, and the exact shape of the mesosome cannot be determined. The dotted line in fig. 4 indicates the probable outline of a portion of one of the inner plates of the mesosome which cannot be seen in its entirety in the type slide. A third point is present at mid-stem, for this can be seen on the other inner plate, which is visible in a vertical view in the type slide.

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[7]Recognized as valid, with the commoner synonyms, and notes on the species.

5. **alogistus** Dyar, 1918. Ins. Mens. Mens. 6:126. Surinam. Lectotype here selected: slide 972, ♯F, U.S.N.M. Synonym: *megapus* Root, 1927. Described from a series of four males and one female, with associated larval skins, taken by the Bonnes in Surinam. The larval skins are labeled C, E, F and G. The terminalia of the corresponding male of E cannot be found in the United States National Museum collection, although the remainder of the specimen is present: male G is intact. The male F was apparently selected as the lectotype by Dyar; its associated larval skin, also labeled F, is that of a typical *Mochlostyrax*, with the scales on the 8th abdominal segment in a row. But the larval skin labeled C, supposedly that of the single female of the type series, is actually that of a species of *Culex*, subgenus *Culex*. The female specimen is so mouldy that characters are difficult to see, but it appears to be a *Mochlostyrax*, so that we suspect an error has been made in associating it with the larva labeled C.

The type male is associated with a larval skin in which the eighth abdominal segment has a few comb-scales in a row. We have a male from Colombia, definitely *alogistus*, with a leaf on the outer division of the lobe of the sidepiece, with an associated larval skin in which the comb-scales are in a patch, as in *vexillifer*. Further confusion results from the examination of the junior author's larvae from Almirante, Panama (which, however, are not definitely associated with males), but which have the comb-scales in a row. The possibility exists that there are two closely similar species, differing only in the larva; future investigations must be made to settle the question.

6. **amitis** Komp, 1936. Ann. Ent. Soc. Amer. 29:333. Quiriquire (near Maturin), Venezuela.

7. **andricus** Root, 1927. Amer. Jour. Hyg. 7:592. Lassance (Minas Geraes) Brazil.

8. **anips** Dyar, 1916. Ins. Ins. Mens. 4:48. San Diego, California, U.S.A. Nearctic (Southern California). Recently recovered in southern California. Hitherto known only from a single male

9. **atratus** Theobald, 1901. Mon. Culic. 2:55. Jamaica and Trinidad, B.W.I. Synonym: *advieri* Senevet, 1938. This widespread West Indian species should be readily recognized by the characteristic filaments on the sidepiece, basad of the inner division of the lobe, and by the narrowly produced apices of the lobes of the ninth tergite.

10. **bastagarius** Dyar and Knab, 1906. Proc. Biol. Soc. Wash. 19:170. Laventille, Trinidad, B.W.I. This species has been redescribed under a multitude of synonyms, including *vapulans* Dyar, 1920; *alfaroi* Dyar, 1921; *innominatus* Evans, 1924; *cuclyx* Dyar and Shannon, 1924. The mesosome presents considerable variation in shape according to its orientation in the mount. The closely appressed, parallel arms and rods of the inner division of the lobe of this sidepiece, and the basally produced ninth tergite lobes, are especially diagnostic. Occasionally the basal prolongation of the tergite lobe may have several setae on it: usually this portion is bare.

Vapulans Dyar, 1920, was synonymized under *bastagarius* by the junior author (1935). The types are two males from Surinam, "from larvae in a pool near Parimaribo." One of these cotypes is labeled

"Surinam BB 330, Mrs. J. Bonne-Wepster." This slide corresponds with Dyar's original description (Ins. Ins. Mens. 8: 69), and is herewith selected as the lectotype of the species. The other cotype of *"vapulans,"* labeled "J. Bonne-Wepster, Surinam, M 94 (P 2)," is, we think, an undescribed species, determined as such by the junior author during this study. We hope to describe this and several other new species which have come to light during the course of this work, in a subsequent paper.

11. **batesi** Rozeboom and Komp, 1948. Jour. Parasit. 34: 403. Villavicencio (Meta), Colombia. The adult has a small patch of setae on the postnotum, as in the sabethine mosquitoes, and in some *Deinocerites* species.

12. **bequaerti** Dyar and Shannon, 1925. Jour. Wash. Acad. Sci. 15: 40. Rio Branco, Amazonas, Brazil. The true shape of the mesosome is probably more nearly like that of *theobaldi* (q.v.), rather than as illustrated from the undissected type slide.

13. **breviculus** Senevet and Abonnenc, 1939. Arch. Inst. Past. d'Algerie 17: 110. Saut-Tigre, French Guiana.

14. **carcinophilus** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14: 220. Trujillo, Santo Domingo, W.I. This species is closely related to *plectoporpe*, *phlogistus*, and *inhibitator*. All four species have a large leaf inserted on the outer division of the lobe, basal to the filaments, from a very large tubercle. The shape of the mesosome is apparently identical in the last three species, but the mount of the type male (reared from the larva, which is the designated type) of *carcinophilus* is in such extremely poor condition that it is impossible to determine the actual shape of the inner plate. The portion that can be seen resembles somewhat the mesosome of the three other species, but no subapical dorsal point is visible. For this reason *carcinophilus* may be misplaced in the key, and additional material from the type locality will be required to establish its true position. The rounded prominence on the clasper, with the stout eye-seta, will easily separate it from the three species mentioned above.

15. **cauchensis** Floch and Abonnenc, 1945. Inst. Past. Guyane Francaise, Publ. 112: 1. Caux, French Guiana. A very bizarre species, easily separated.

16. **caudelli** (Dyar and Knab), 1906 (*Mochlostyrax*). Jour. N. Y. Ent. Soc. 14: 224. Arima, Trinidad. A common species of wide distribution.

17. **chrysonotum** Dyar and Knab, 1908. Proc. U. S. Nat. Mus. 25: 57. Panama Canal Zone. Lectotype here selected: Slide 335, No. 417, Jennings' notes. Synonym: *aurilatus* Senevet and Abonnenc, 1939. Dyar (1928) states that in *chrysonotum* the outer division of the lobe of the sidepiece is without a leaf, which led Senevet and Abonnenc to redescribe the species. All of the authors' specimens from Panama show a narrow, striate leaf, as does the lectotype male from Panama. A very common species in Panama.

18. **comatus** Senevet and Abonnenc, 1939. Arch. Inst. Past. d'Algerie 17: 103. Saut-Tigre, French Guiana. This interesting species

is readily recognized by the "beard" on the inner curvature of the head
of the clasper. We have recently received a specimen collected at
Villavicencio, Colombia, by the staff of the Rockefeller Foundation.

19. **commevynensis** Bonne-Wepster and Bonne, 1920. Ins. Ins.
Mens. 7:176. Alkmaar, Surinam. No specimens of this are in the
United States National Museum. The junior author (1935) suspected
that this might be *dunni* Dyar, but the Bonnes (1925, fig. 37) show a
hair-like lower spine on the inner division of the lobe of the sidepiece,
while *dunni* has several spines in this position. This species has recently
been taken in Panama by Dr. Pedro Galindo, and the specimen seen
by the junior author. Dr. Galindo kindly sent us a camera lucida
drawing of the sidepiece and ninth tergite lobes, with other information.
Later the senior author found a specimen in his collection from
Colombia, which agrees with Galindo's drawings, with one exception,
in that the leaf between the outer division of the lobe and the apex of
the sidepiece is not so expanded and truncate as is shown in Galindo's
drawing and in the Bonne's figure (No. 37).

20. **comminutor** Dyar, 1920. Ins. Ins. Mens. 8:70. Surinam.
Synonym: *productus* Senevet and Abonnenc, 1939. The undissected
terminalia of the type do not permit a lateral view of the mesosome
(fig. 20), but the inner plate is obviously L-shaped, with a third median
point at the angle. The characteristic ninth tergite lobes and the
widely divaricate arms of the inner division of the lobe of the side-
piece are illustrated for *productus* by Senevet & Abonnenc (1939), and
a specimen received from the Institut Pasteur in French Guiana can
not be separated from the type of *comminutor*.

21. **conspirator** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc.
14:127. Almoloya, Mexico. Synonyms: *holoneus* Dyar, 1921; *fatuator*
Dyar, 1924; *inducens* Root, 1928; *macaronensis* Dyar and Núñez-Tovar,
1927. Very common in Panama.

22. **coppenamensis** Bonne-Wepster and Bonne, 1920. Ins. Ins.
Mens. 7:173. Kabelstation, Surinam. Apparently rare.

23. **corentynensis** Dyar, 1920. Ins. Ins. Mens. 8:65. Surinam.
Lectotype here selected: Slide BB 643, U.S.N.M. Apparently rare.

24. **crybda** Dyar, 1924. Ins. Ins. Mens. 12:184. Murindo,
Colombia. This species was formerly considered a synonym of
taeniopus, but the junior author, and later his friend Dr. Pedro Galindo,
obtained reared material of both species in Panama. The larva of the
species here described as *taeniopus* is apparently indistinguishable from
that of *crybda*, but the pupal trumpet of *taeniopus* is aberrant for a
Melanoconion, as it is widened and flattened at the tip, with a peculiar
transverse cleft; that of *crybda* is normal, long and funnel-shaped.
The terminalia of the two species are apparently indistinguishable.
The adults of *taeniopus* have white-ringed tarsi, but those of *crybda*
have black tarsi.

25. **distinguendus** Dyar, 1928. Mosq. Amer.:305. Mojingo Swamp
(Atlantic side), Panama Canal Zone. Lectotype here selected: Slide
2327, U.S.N.M.

26. **dunni** Dyar, 1918. Ins. Ins. Mens. 6:123. Mandingo River,
Panama Canal Zone. Synonyms: *ruffinis* D. & S., 1924; *exedrus* Root,

1927. Very common. The type locality as given in the original description is "Mandingo River, Panama." There are at least *two* Mandingo Rivers in Panama. One is a large river flowing northeast and emptying into the Gulf of San Blas on the Atlantic Coast at approximately 9° 35′ N. latitude and 79° W. longitude; the other is in the Panama Canal Zone, and flows east, emptying into the Panama Canal on the west bank, nearly opposite the railroad bridge across the Chagres River, opposite the town of Gamboa. It is reasonably certain that this latter river in the Panama Canal Zone, not the Republic of Panama, is the type locality. The river in the Republic is in rather inaccessible Indian country, and probably was never visited by Lawrence Dunn, the collector. We would like to make a plea for better and more specific localities for type material, and for collections in general. During the course of this study we have encountered several other instances of incomplete information regarding localities, which we have noted in their proper places, and which we have unraveled with fair certainty.

27. **dyius** Root, 1927. Amer. Jour. Hyg. 7:587. Brazil. Lectotype here selected: Slide No. 11, F. M. Root, 1925, U.S.N.M. Root, in his original description says: "The male specimen from which the type slide was made has unfortunately been lost, and no record remains of the locality and date. It was probably obtained in the coastal lowlands of the state of Rio de Janeiro in May or June, 1925." However, a slide labeled in Root's handwriting is in the United States National Museum collection as the type of *dyius*, labeled "*dyius* Root. Brazil 1925, F. M. Root, No. 11." A search of the correspondence between Root and Dyar reveals that Root took this specimen to the United States National Museum in February, 1927, to discuss it with Dyar, under the number 11. This specimen is undoubtedly the type male of *dyius*, as it corresponds with Root's figure (1927, Plate 10, fig. 14), and is herewith selected as the lectotype, if such selection seems necessary. Dyar (1928) listed *dyius* as a synonym of *elevator*, and described the latter as being without a leaf on the outer division of the lobe. However, *elevator* does possess a leaf, whereas *dyius*, as described by Root, has a small seta instead. We therefore are establishing *dyius* as a valid species.

28. **eastor** Dyar, 1920. Ins. Ins. Mens. 8:71. Surinam. Synonym: *manaosensis* Evans. This synonymy was verified by Miss Evans to the junior author. Lane (1939) continues to list *manaosensis* as a valid species. See Komp (1935). Apparently a widespread and common species.

29. **educator** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14:217. Rio Aranjuez, Puntarenas, Costa Rica. Synonyms: *vaxus* Dyar, 1920; *bibulus* Dyar, 1920; *aneles* Dyar & Ludlow, 1922. Dyar (1928) says there is no leaf on the outer division of the lobe of the sidepiece; actually a narrow striate leaf is present, inserted near the middle filament. A very common species.

30. **egcymon** Dyar, 1923. Ins. Ins. Mens. 11:67. Tabernilla, Panama Canal Zone. Common in Panama.

31. **elephas** Komp, 1936. Ann. Ent. Soc. Amer. 29:328. Juan Diaz (E. of Panama City), Panama. Rare, but collected by the junior

author some years ago, and recently by Dr. Pedro Galindo, both in Panama.

32. **elevator** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14: 217. Limon, Costa Rica. Synonyms: *dornarum* D. & S., 1924; *curryi* Dyar, 1926; *bonneti* Senevet, 1938. Dyar (1928) states that there is no leaf on the outer division of the lobe of the sidepiece, but one is present. Senevet (1938) correctly describes this in *bonneti*. Lane (1939) does not list *curryi* Dyar, either as a species or as a synonym. A very common species.

33. **equinoxialis** Floch & Abonnenc, 1945. Inst. Past. Guyane Francaise, Publ. 114: 3. Camp Rochambeau (S. of Cayenne), French Guiana. Apparently rare.

34. **erraticus** (Dyar and Knab), 1905 (*Mochlostyrax*). Jour. N. Y. Ent. Soc. 14: 224. Baton Rouge, Louisiana, U.S.A. Synonyms: *leprincei* D. & K., 1907; *egberti* D. & K., 1907; *trachycampa* D. & K., 1909; *peribleptus* D. & K., 1917; *homoeopas* Dyar and Ludlow, 1921; *tovari* Evans, 1924; see King and Bradley (1937). A very common species, of wide nearctic and neotropical distribution.

35. **evansae** Root, 1927. Amer. Jour. Hyg. 7: 593. Mage, [State of Rio de Janeiro] Brazil; lectotype here selected: Slide No. 30-1, Mage, Brazil, N. C. Davis, II-26-25. Root fails to mention the State of Brazil in which Mage is located. We have inserted this in brackets.

36. **flabellifer** Komp, 1936. Ann. Ent. Soc. Amer. 29: 323. Santa Rosa, Colon Province, Panama. A rare species, recently found in Mexico by the late Alfonso Dampf.

37. **hesitator** Dyar and Knab, 1907. Jour. N. Y. Ent. Soc. 15: 205. Las Cascadas, Panama Canal Zone. Synonym: *colombiensis* Dyar, 1924. There is some evidence that *hesitator* and *pilosus* (q.v.) are intergrades of one species, varying in form and vestiture of the lobes of the ninth tergite. The *hesitator* form seems to be neotropical, and much less common than the ubiquitous *pilosus* form.

38. **idottus** Dyar, 1920. Ins. Ins. Mens. 8: 77. Surinam. Apparently rare.

39. **implicatus** Senevet and Abonnenc, 1939. Arch. Inst. Past. d'Algerie 17: 99. "Le petit Saut," Sinnamary River, French Guiana. We have seen no material of this species; its position in the key is based on the original description. Figure 39 was redrawn from Senevet and Abonnenc.

40. **inadmirabilis** Dyar, 1928 (new name). Mosq. Amer.: 297. São Paulo, Brazil. A leaf is present on the outer division of the lobe of the sidepiece, which is not mentioned by Dyar (1928). The leaf, as illustrated from the type slide (fig. 40) may have been broken, which would account for its peculiar truncated appearance. The type terminalia have no seta at midstem on the inner division of the lobe of the sidepiece (as in *taeniopus*), a character which Dyar (1928, key, p. 275, couplet 62) used to key out this species. Actually, a seta is at the base of the outer division of the lobe, which, in one of the sidepieces of the type, is superimposed on the inner division of the lobe.

41. **inhibitator** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14: 216. San Francisco Mountains, Santo Domingo, W. I. Formerly

confused with *erraticus* D. & K., but separated by King and Bradley (1937). In all but his first three references to this species, Lane (1939) follows the old incorrect synonymy.

42. **innovator** Evans, 1924. Ann. Trop. Med. and Parasit. 18: 373. Amazon River, Brazil.

43. **intrincatus** Brèthes, 1916. Ann. Mus. Nac. Hist. Nat., Buenos Aires 28: 214. San Isidro (8 miles north of the city of Buenos Aires), Argentina. Synonyms: *cenus* Root, 1937; *xivylis* Dyar, 1920. The type is not in the United States National Museum. We have compared Brèthes' original figure, and find it corresponds, so far as the sidepiece is concerned, almost exactly with Root's type slide of *cenus* from Brazil. From a study of the type slide of *xivylis* (we have retained the original spelling) in the United States National Museum, labeled "BB 714a, Surinam, J. Bonne-Wepster," the junior author determined during the course of this work that it is *intrincatus*. The description of *xivylis* in Dyar (1928, p. 331) is actually that of *cuclyx* D. & S., 1924, which is a synonym of *bastagarius* D. & K., 1906, as determined by the junior author (1935), and not of *xivylis*, as Dyar (1928) has it. Figure 286 in Dyar (1928) was also drawn from the type slide of the male of *cuclyx*. Apparently *intrincatus* is widespread but rare.

44. **iolambdis** Dyar, 1918 Ins. Ins. Mens. 6: 106. Panama. Locally common in Panama.

45. **jubifer** Komp and Brown, 1935. Ann. Ent. Soc. Amer. 28: 254. Mojingo Swamp, (Atlantic side) Panama Canal Zone. Found to be locally common east of Panama City by Dr. Pedro Galindo, who discovered the larva in ground-pools.

46. **latisquama** (Coquillett), 1906 (*Tinolestes*). Proc. Ent. Soc. Wash. 7: 185. Limon, Costa Rica. Lectotype here selected: intact male, No. 344 c, U.S.N.M. Very common.

47. **limacifer** Komp, 1936. Ann. Ent. Soc. Amer. 29: 325. Chase, Limon Province, Costa Rica. Apparently rare; has been found in the Canal Zone.

48. **lucifugus** Komp, 1936. Ann. Ent. Soc. Amer. 29: 331. Quiriquire (near Maturin), Venezuela. Locally common in northeastern Trinidad, B.W.I.

49. **madininensis** Senevet, 1936. Arch. Inst. Past. d'Algerie 14: 129. Trinite, Martinique, French West Indies. No material was available for study; figure 49 was redrawn from Senevet. From Senevet's description it appears that the mesosome is identical with that of *elevator*. The species should be easily identifiable, as the sulcus in the clasper is unusual, and the filaments of the lobe of the sidepiece differ from those of *elevator*.

50. **maroniensis** Bonne-Wepster and Bonne, 1919. Ins. Ins. Mens. 7: 175. No material of *maroniensis* was available for study, but the separation of this species from *albinensis* by the Bonnes does not seem warranted, judging by the characters of the male type of *albinensis*, which we examined, and by their figure of *maroniensis* (no. 46, 1925).

51. **maxinocca** Dyar, 1920. Ins. Ins. Mens. 8: 71. Surinam. Lectotype here selected: slide BB 971, U.S.N.M. Closely related to *C. distinguendus*, but apparently rarer.

52. **menytes** Dyar, 1918. Ins. Ins. Mens. 6:125. Trinidad River, Panama.[8] Synonym: *haynei* Komp & Curry, 1936. These authors were misled by Dyar's inaccurate figure (224, 1928), and correctly figured the terminalia under this name. Floch was about to publish a new name, being similarly misled, but the junior author identified his material as *menytes*.

53. **mulrennani** Basham, 1948. Ann. Ent. Soc. Amer. 41:1. Big Pine Key, Monroe County, Florida, U.S.A. A rare nearctic species, overlooked by many. We note that the slide labeled "Slide C5X, 24 July 1947" is in much better condition than the designated holotype slide, and we have drawn our figure from this specimen in the United States National Museum.

54. **Species A.** The species here considered is actually a new and hitherto undescribed species. The information leading to this conclusion was obtained too late to make the necessary changes in the present paper. We hope to describe the new species in a subsequent publication.

55. **mutator** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14:216. Córdoba, Mexico. Lectotype here selected: slide 1811, Knab 259b, U.S.N.M. The junior author (1935) showed that *alfaroi* Dyar, 1921, given by Dyar (1928) as a synonym of *mutator*, is *bastagarius* D. & K. Apparently rare.

56. **nicceriensis** Bonne-Wepster and Bonne, 1920. Ins. Ins. Mens. 7:174. Kabelstation, Surinam. No material is available for study, and we have placed the species in our key from the characters given in the original description, and are assuming that the inner plate of the mesosome is L-shaped, with a third point at the angle. Figure 56 was redrawn from Bonne and Bonne-Wepster, 1925.

57. **nigrescens** (Theobald) 1907 (*Danielsia*). Mon. Culic. 4:248. Sto. Amaro (a small town due southwest of the city of São Paulo) Brazil.[9] Synonym: *clarki* Evans, 1924. There is no material in the United States National Museum. Our figure is drawn from a specimen taken by Root in Brazil, which agrees with Evans' description and figure of *clarki*.

58. **nigrimacula** Lane and Whitman, 1943. Rev. Ent. 14:403. Federal District, Brazil. The adults of this species, and of *ocellatus* (=*automartus*), *punctiscapularis*, and *C.* (*Microculex*) *stonei*, resemble

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each other in having a large dark spot on the scutum before the wing-base. Figure 58 was redrawn from Lane and Whitman.

59. **ocellatus** Theobald, 1903. Mon. Culic. 3:222. São Paulo, Brazil. Synonym: *automartus* Root, 1927. Lane and Whitman (1943) have shown that Theobald's mosquito is a *Melanoconion*, later described by Root (1927) as *automartus*; they described the true *Microculex*, which had been confused with *ocellatus*, as *C. stonei*. *Ocellatus* is very close to *punctiscapularis* F. & A., 1946.

60. **oedipus** Root, 1927. Amer. Jour. Hyg. 7:588. Lectotype here selected: slide no. 8-1, F. M. Root, 11-4-15, Mage, Brazil.[10] Dyar (1928) synonymized this species with *phlogistus* Dyar. However, *oedipus* is valid, and differs extensively from *phlogistus*. *Oedipus* has no leaf on the outer division of the lobe of the sidepiece, and the apical portion of the upper arm of the inner division of the lobe is notably swollen. Lane (1939) also incorrectly synonymized *oedipus* under *phlogistus* Dyar.

61. **opisthopus** Komp, 1926. Ins. Ins. Mens. 14:44. Puerto Castilla, Honduras. Synonym: *mychonde* Komp, 1928.

62. **paracrybda** Komp, 1936. Ann. Ent. Soc. Amer. 29:330. Juan Diaz (E. of Panama City), Panama. Rare.

63. **peccator** Dyar & Knab, 1909. Smiths. Misc. Colls., Quart. Iss. 52:256. Scott, Arkansas, U.S.A. Lectotype here selected: slide 396, J. K. Thibault, Scott, Ark. U.S.N.M. This species is nearctic in distribution. See King and Bradley, 1937.

64. **phlabistus** Dyar, 1920. Ins. Ins. Mens. 8:63. Surinam. Our illustration of the mesosome of the type is not entirely accurate, because it cannot be seen in lateral view in the type slide; no other material is available. It is probably L-shaped, similar to that of *chrysonotum*.

65. **phlogistus** Dyar, 1920. Ins. Ins. Mens. 8:61. Surinam. Dyar (1928) synonymized *oedipus* Root with this species, and described the terminalia, not from the type slide of *phlogistus*, but from Root's slide of *oedipus*. Therefore the terminalia of *phlogistus* are first described correctly in the present paper. *Phlogistus* has a large leaf from a prominent tubercle on the outer division of the lobe of the sidepiece, which is absent in *oedipus*. Dyar also believed that *maroniensis* B.-W. & B. might be s synonym of *phlogistus*, but the presence of a leaf in *phlogistus* makes it seem more likely that *maroniensis* is *albinensis* B.-W. & B.

66. **pilosus** Dyar and Knab, 1906. Jour. N. Y. Ent. Soc. 14:224. Santa Lucrecia, (State of Vera Cruz, S. W. of Coatzacoalcos, longitude 95° W.) Mexico. Synonyms: *floridanus* D. & K., 1906; *curopinensis* B.-W. & B., 1920; *radiatus* Senevet & Abonnenc, 1939. These latter authors separated *radiatus* from *pilosus* by the presence in the former of a basal horn on the mesosomal plate above the basal hook, and the presence of a leaflike filament on the under side of the outer division of the lobe of the sidepiece. These structures are actually present in

[10]Mage is a town in the State of Rio de Janeiro, a short distance northeast of the city of Rio de Janeiro.

pilosus, but were not mentioned in Dyar's (1928) description. Exceedingly common. Nearctic and neotropical.

67. **plectoporpe** Root, 1927. Amer. Jour. Hyg. 7: 589. Bangu, Brazil.[11] We believe that the mesosome is more like that of *inhibitator* or of *phlogistus* rather than as illustrated by Root. Fairly common locally in northern Panama.

68. **portesi** Senevet and Abonnenc, 1941. Arch. Inst. Past. d'Algerie 19: 41. French Guiana. Synonym: *cayennensis* Floch and Abonnenc, 1945. *C. portesi* is remarkable in that a broad leaf is inserted at the lower angle of the outer division of the lobe of the sidepiece. The hook-tipped filament is absent from the specimen in the United States National Museum; however, the insertion is present and Floch and Abonnenc illustrate this filament in their figure of *cayennensis*. Other distinctive features are the membranous triangular projection at the middle of the clasper, and the conical ninth tergite lobes, with their long setae. Apparently the inner plates of the mesosome had been lost in the specimen from which *portesi* was described, but they are illustrated in the later paper on *cayennensis*, from which our illustration of the mesosome was taken. Floch and Abonnenc (1947) note that *cayennensis* is the same as *portesi*, and compare the former with *bequaerti*, which it in no wise resembles, but do not mention *vomerifer*, which is very closely allied to *portesi*, differing in minor details.

69. **psatharus** Dyar, 1920. Ins. Ins. Mens. 8: 173. Colón, Panama. Lectotype here selected: specimen labeled "Type, Colón, Panama July 28, 1920, W. S. Chidester. No. 1318." U.S.N.M. To date known only from the Atlantic side of the Panama Canal Zone, where it is locally common.

70. **punctiscapularis** Floch & Abonnenc, 1946. Inst. Past. Guyane Francaise, Publ. 122: 1. Crique Anguille (?), French Guiana. This species resembles *ocellatus* Theobald very closely. We suspect that Lane and Whitman (1943) may have had *punctiscapularis* before them when they mention *ocellatus* (p. 402), as they say, "Peca lateral com o contorno arredondado e cerdas longas. . . . " Such long hairs (cerdas longas) are present on the outer curvature of the sidepiece of *punctiscapularis*, and not present in *ocellatus*. We have examined material of *punctiscapularis* received from Dr. Floch, and of *automartus* (= *ocellatus*) in the United States National Museum collection.

71. **putumayensis** Matheson, 1934. Proc. Ent. Soc. Amer. 36: 120. Amazon River, Brazil. Synonym: *cavernicolus* Floch and Abonnenc, 1945. The junior author has this from Brazil, nearer the mouth of the Amazon than the probable place of capture of the type. Specimens in the United States National Museum of both *putumayensis* and *cavernicolus* show a leaf inserted in a large tubercle at the base of the outer arm of the outer division of the lobe of the sidepiece. There is no dissected material, so that the mesosome cannot be seen in lateral view; however, the third curved point can be made out, and it is probable that the actual shape of this plate is that of an inverted L, with the upper arm, bearing the terminal points, longer than the lower arm. Apparently rare.

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[11]Bangu is a small suburb across the bay from the city of Rio de Janeiro.

72. **quadrifoliatus** Komp, 1936. Ann. Ent. Soc. Amer. 29: 322. Mojingo Swamp (Atlantic side), Panama Canal Zone. Apparently rare. The junior author has one other male from the Panama Canal Zone.

73. **rabanicolus** Floch and Abonnenc, 1946. Inst. Past. Guyane Francaise, Publ. 120: 1. Raban (?), French Guiana. Apparently rare.

74. **rooti** Rozeboom, 1935. Ann. Ent. Soc. Amer. 28: 251. Panama City, Panama. It is a mystery why this seasonally very common *Mochlostyrax* escaped all previous collectors in Panama. The junior author obtained large numbers of larvae in temporary pools along the road to Chepo in Panama, some years after its discovery.

75. **rorotaensis** Floch and Abonnenc, 1946. Inst. Past. Guyane Francaise, Publ. 120: 3. Rorota, French Guiana. The dotted line in our illustration of the mesosome represents the probable outline of a portion that cannot be seen in the specimen presented to the U. S. National Museum by Dr. Floch. Apparently very rare.

76. **saramaccensis** Bonne-Wepster & Bonne, 1920. Ins. Ins. Mens. 7: 172. Kabelstation, Surinam. No material was available for study, so we have had to depend upon Bonne and Bonne-Wepster (1925) for the placement of this species in our key. The mesosome was redrawn from Bonne and Bonne-Wepster (1925). Apparently very rare.

77. **serratimarge** Root, 1927. Amer. Jour. Hyg. 7: 589. Sant' Anna, State of Rio de Janeiro, Brazil. (Sant' Anna de Japin.) We have retained the spelling of the original description. Locally common in northern Panama.

78. **spissipes** (Theobald), 1903 (*Melanoconion*). Mon Culic. 3: 242. Trinidad, B.W.I. No material was available for examination. The species, as defined by the Bonnes, is allied to *dunni* and *zeteki*. The characters identifying it and fig. 78 were taken from Bonne and Bonne-Wepster (1925), who arbitrarily assigned to *spissipes* a male with the anterior half of the scutum clothed with golden scales, as Theobald describes for the female type of *spissipes*. There is no possible assurance that the Bonne's male is correctly associated with Theobald's female.

(**surukumensis** Anduze, 1941. Rev. Sanid. y Asist. Social (Venez.) 6: 812. This species was listed by the author as a *Melanoconion*, but later he placed it properly in *Isostomyia*. It is a synonym of *conservator* Dyar and Knab.)

79. **sursumptor** Dyar, 1924. Ins. Ins. Mens. 12: 123. Barranquilla, Colombia. Dyar (1928) keys out this species with those lacking a leaf on the outer division of the lobe of the sidepiece. The type has a narrow, striate leaf, inserted near the middle filament.

80. **taeniopus** Dyar and Knab, 1907. Jour. N. Y. Ent. Soc. 15: 100. Bluefields, Nicaragua. Synonym: *epanastasis* Dyar, 1922. *C. taeniopus* was described from a single female from Bluefields, Nicaragua. We have followed Dyar in ascribing to this female a male with the characters of the terminalia as described by Dyar (1928, p. 293). We hereby arbitrarily assign as the male of *taeniopus* D. & K., the specimen of which the male terminalia are mounted on a slide labeled "Mojingo Swamp, Atlantic Side, C. Z. 21.VI.34. W. H. W. Komp." We are aware that the female of *taeniopus* from Nicaragua may be the

same as *opisthopus* Komp from Honduras, and consider this very probable on locality. If this is so, *opisthopus* becomes a synonym of *taeniopus*, and the species now known by this latter name must be called *epanastasis* Dyar. It is likewise probable that *annulipes* Theobald, 1907, from Jamaica, B.W.I., may be the same as *opisthopus*, as the latter has been taken in Puerto Rico by H. D. Pratt.

81. **tecmarsis** Dyar, 1918. Ins. Ins. Mens. 6:124. Trinidad River, Panama. Lectotype here selected: slide labeled "Type 1. Trinidad River, Panama. A. Busck. No. 925." See discussion of locality under *menytes*.

82. **terebor** Dyar, 1920. Ins. Ins. Mens. 8:56. Surinam. The type slide is in very poor condition. Nevertheless, we have included it in the key, in which it runs out with *dyius*.

83. **theobaldi** (Lutz), 1905 (*Melanoconion*). Imp. Med. Feb. 10, 1905. Brazil. Synonym: *chrysothorax* Newstead and Thomas, 1910 (not Peryassú). The scutum of this species, like that of *chrysonotum*, is golden-scaled on the anterior half. The mesosome differs from that of *chrysonotum*, according to the characters given in our key. The terminalia appear to be identical with those of *educator*, so that these two species can only be separated from one another by the coloration of the scutum.

84. **thomasi** Evans, 1924. Ann. Trop. Med. Parasit. 18:371. Manaos, Brazil. No material of this species was available, and its position in our key and figure 84 are based on Evans's description (1924).

85. **tournieri** Senevet and Abonnenc, 1939. Arch. Inst. Past. d'Algerie 17:105. Crique Mangue, Saut-Tigre, French Guiana. No material was available for study, so we had had to depend upon the original description for the characters in our key, and illustration.

86. **trifidus** Dyar, 1921. Ins. Ins. Mens. 9:115. Tiribi, Costa Rica. Lectotype here selected: slide 1436, U.S.N.M. Recently found in both Mexico and Panama, by Dampf and Galindo, respectively.

87. **unicornis** Root, 1928. Mosq. Amer.:291. Maracay, Venezuela. Lectotype here selected: specimen no. 1 (on left); slide labeled "Maracay, Venezuela, June 27, 1927. Nos. 92-1, 2, 3."[12] U.S.N.M.

88. **vexillifer** Komp, 1936. Ann. Ent. Soc. Amer. 29:320. Barro Colorado Island, Panama Canal Zone. Lectotype here selected: the slide of the male terminalia so labeled in the United States National Museum collection. It is the only *Mochlostyrax* larva described with the comb-scales of the eighth abdominal segment in a patch. Lane (1939) lists this under *Melanoconion*.

89. **vomerifer** Komp, 1932. Psyche 39:79. Almirante, Bocas del Toro Province, Panama. This species resembles *portesi* S. & A. very closely, but is not mentioned in the description of the latter. *Vomerifer* seems to be locally very common in Panama, near the type locality.

90. **ybarmis** Dyar, 1920. Ins. Ins. Mens. 8:57. Parimaribo, Surinam. Synonym: *jonistes* Dyar, 1920.

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[12]Three male terminalia of *unicornis* are mounted under one coverglass on the type slide. No. 1 is assumed to be the specimen farthest from the red cotype label.

91. **zeteki** Dyar, 1918. Ins. Ins. Mens. 6:122. Gatun, Panama
Canal Zone. Synonyms: *loturus* Dyar, 1925; *ensiformis* Bonne and
Bonne-Wepster, 1919. Dyar (1928) describes *zeteki* as having a large
leaf and two small setae on the outer division of the lobe of the sidepiece.
Actually there are four or five setae, in addition to the leaf. The inner
division of the lobe bears two stout semi-cylindrical filaments, and a
third more slender filament arising basal to these filaments. It is
possible that, in their attempt to revive the name *ensiformis*, Senevet
and Abonnenc (1939) were dealing with *zeteki*. The slide of the type
male terminalia of *ensiformis* is in extremely poor condition, but they
are apparently the same as those of *zeteki* Dyar. The pinned adult
male does not show a more extensive development of the "creamy
golden, narrow curved scales" (Bonne & Bonne-Wepster, 1925) on the
scutum as does *zeteki*. The junior author has noted that the pattern of
golden scales on the scutum of *zeteki* is present in recently emerged
adults, but that it fades rapidly.

We have revised Dyar's spelling of the specific name, as the species
was named for Mr. James Zetek, who sent Dyar the original material
(see Ins. Ins. Mens. 6:122, 1918). According to the international
rules of nomenclature, article 14, "If the name is a modern patronymic,
the genitive is always formed by adding, to the exact and complete
name, an i if the person is a man. . . ." We do not know why
Dyar did not follow this rule, except that the letter K was not in the
Latin alphabet.

SPECIES OF UNCERTAIN POSITION OR VALIDITY

The species of *Melanoconion* of which the males are unknown, or of
which the male terminalia have not been described, are listed below.
Their position and validity will remain unknown until the male
terminalia have been described.

1. **chrysothorax** Peryassú, 1908. (Note Newstead and Thomas,
1910 (=*theobaldi* Lutz, 1905).) The male has white-ringed tarsi.
The terminalia have not been described. Brazil.

2. **decorator** Dyar and Knab, 1906. Described from larvae in
bamboo, the male unknown. The junior author suggests that this
may be *distinguendus* Dyar.

3. **epirus** Aiken, 1909. Female only known. British Guiana.

4. **fasciolatus** Lutz, 1905. Female only known. Brazil.

5. **gravitator** Dyar and Knab, 1906. Described from larvae in
bromeliads. Mexico.

6. **humilis** Theobald, 1901. The male is known, but apparently
the terminalia have not yet been described. Brazil.

7. **indecorabilis** Theobald, 1903 (not Dyar, 1921). The male is
known, but the terminalia apparently have not been described. Brazil.

8. **lugens** Peryassú, 1908. The male is known, but the terminalia
apparently have not been described. Brazil.

9. **luteopleurus** Theobald, 1903. Female only known. Brazil.

10. **nigricorpus** Theobald, 1901. Female only known. Brazil.

11. **simulator** Dyar and Knab, 1906. Described from larvae in a
ground-pool. Trinidad, B.W.I.
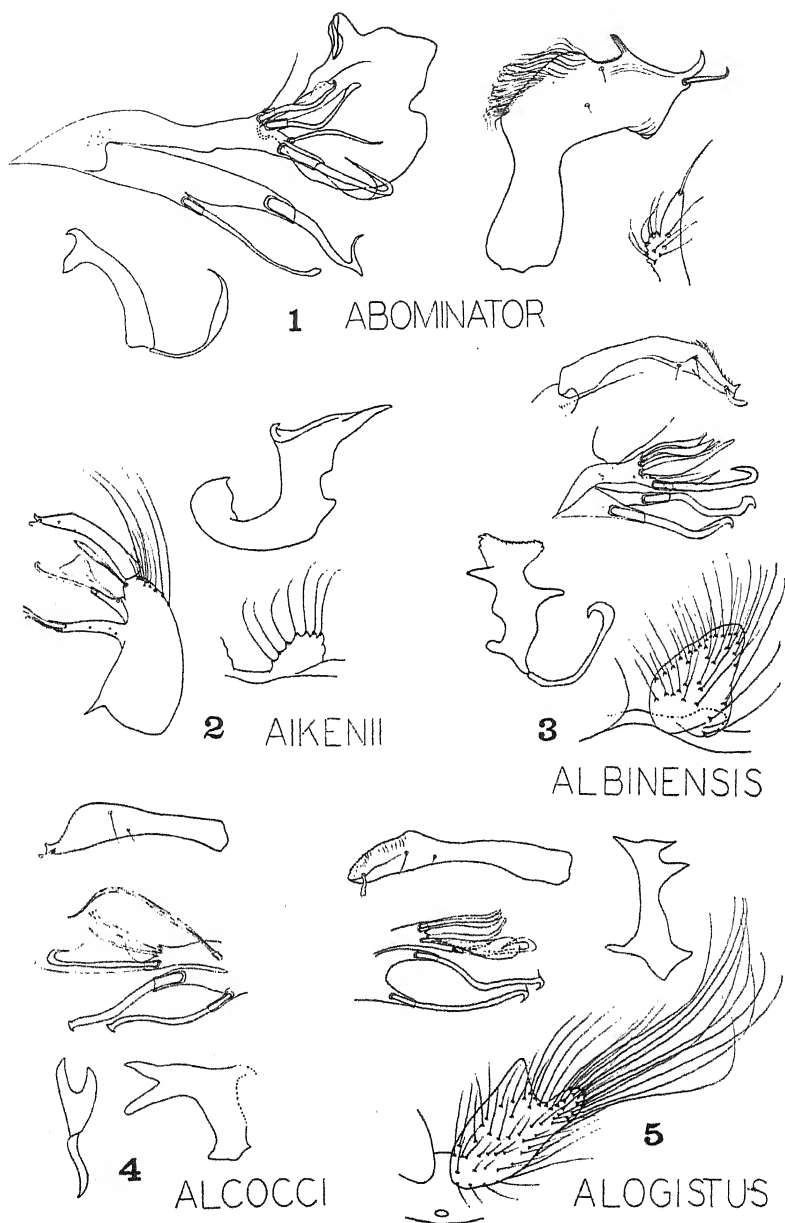
Male genitalia of *Culex*. Fig. 1, *C. abominator* Dyar and Knab. Fig. 2, *C. aikenii* (Aiken). Fig. 3, *C. albinensis* Bonne-Wepster and Bonne. Fig. 4, *C. alcocci* Bonne-Wepster and Bonne. Fig. 5, *C. alogistus* Dyar.
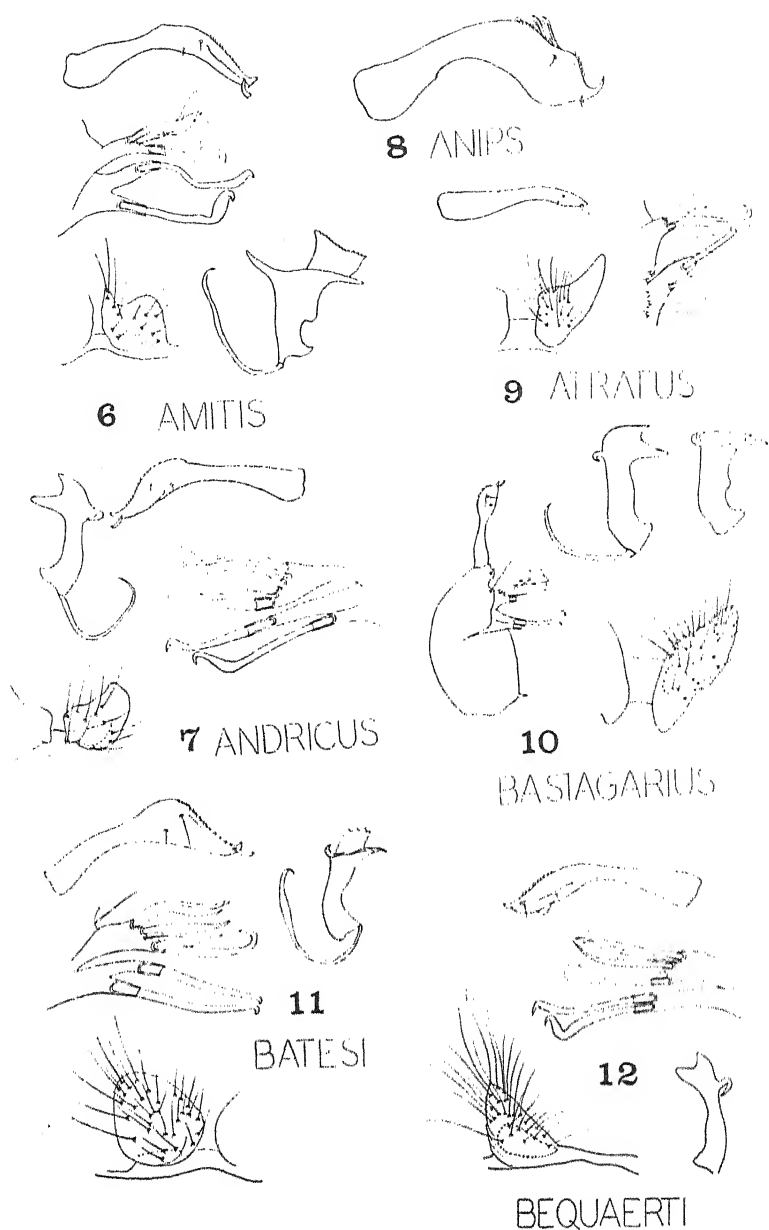
Male genitalia of *Culex*. Fig. 6, *C. amitis* Komp. Fig. 7, *C. andricus* Root. Fig. 8, *C. anips* Dyar. Fig. 9, *C. atratus* Theobald. Fig. 10, *C. bastagarius* Dyar and Knab. Fig. 11, *C. batesi* Rozeboom and Komp. Fig. 12, *C. bequaerti* Dyar and Shannon.

13 BREVICULUS

14 CARCINOPHILUS

15 CAUCHEI ISIS

16 CAUDELLI
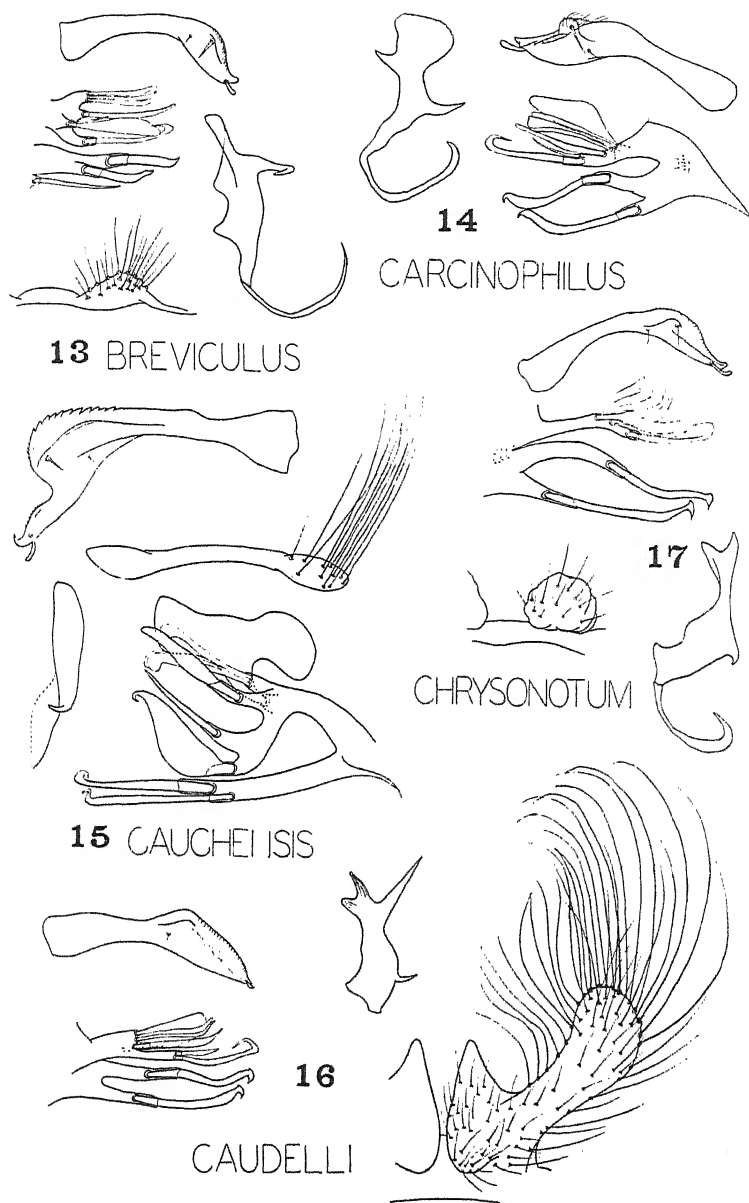
17 CHRYSONOTUM

Male genitalia of *Culex*. Fig. 13, *C. breviculus* Senevet and Abonnenc. Fig. 14, *C. carcinophilus* Dyar and Knab. Fig. 15, *C. cauchensis* Floch and Abonnenc. Fig. 16, *C. caudelli* (Dyar and Knab). Fig. 17., *C. chrysonotum* Dyar and Knab.
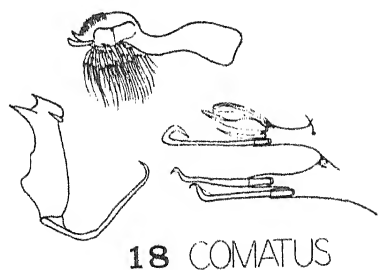
18 COMATUS

19
COMMEVYNEHSIS

20
COMMINUTOR
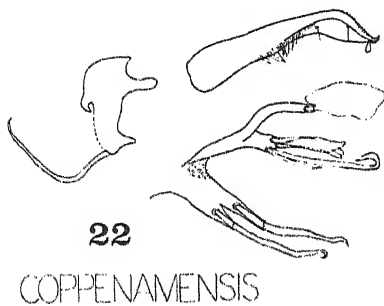
21 CONSPIRATOR

22
COPPENAMENSIS
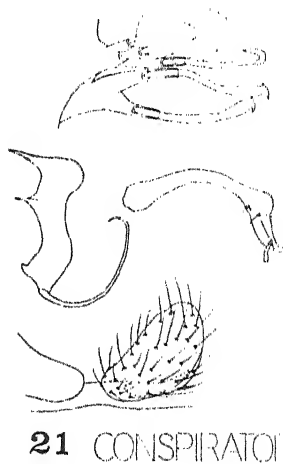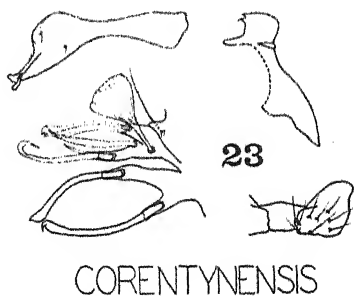
23
CORENTYNENSIS
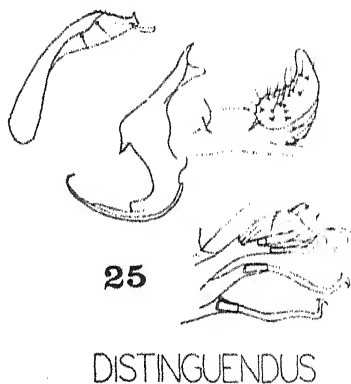
25
DISTINGUENDUS

Male genitalia of *Culex*. Fig. 18, *C. comatus* Senevet and Abonnenc. Fig. 19, *C. commevynensis* Bonne-Wepster and Bonne. Fig. 20, *C. comminutor* Dyar. Fig. 21, *C. conspirator* Dyar and Knab. Fig. 22, *C. coppenamensis* Bonne-Wepster and Bonne. Fig. 23, *C. corentynensis* Dyar. Fig. 24, omitted. Fig. 25, *C. distinguendus* Dyar.
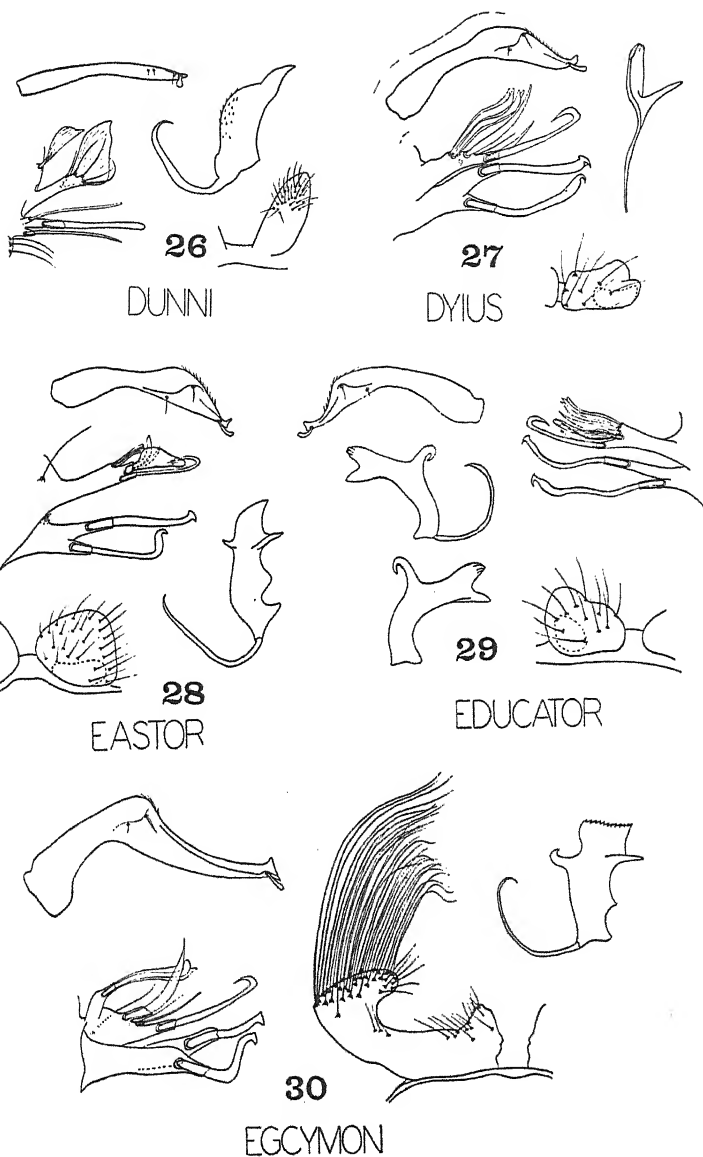
Male genitalia of *Culex*. Fig. 26, *C. dunni* Dyar. Fig. 27, *C. dyius* Root. Fig. 28, *C. eastor* Dyar. Fig. 29, *C. educator* Dyar and Knab. Fig. 30, *C. egcymon* Dyar.
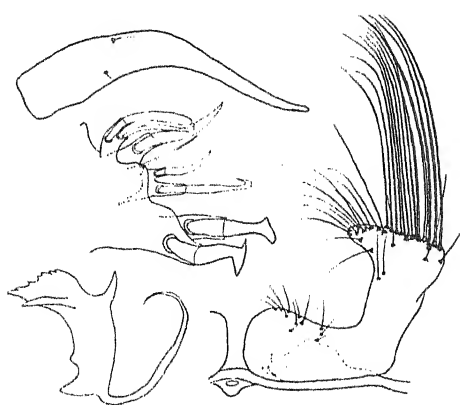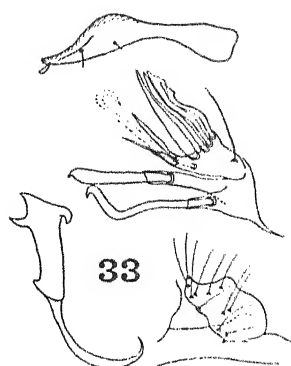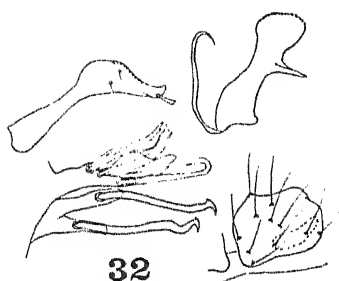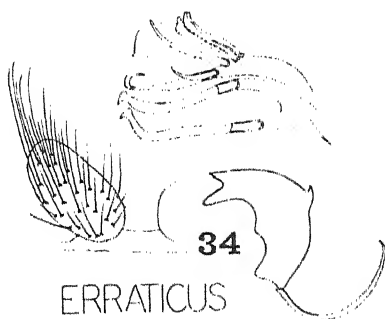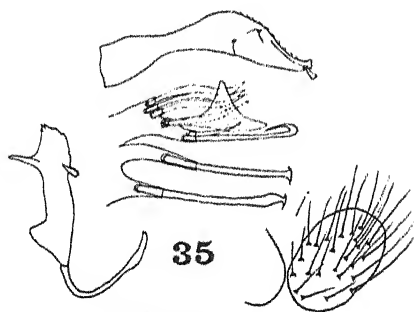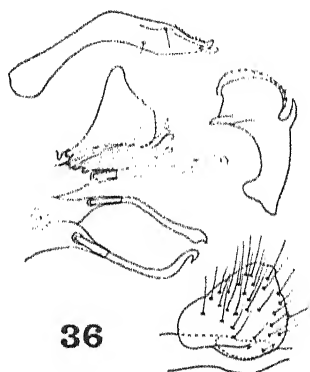
Male genitalia of *Culex*. Fig. 31, *C. elephas* Komp. Fig. 32, *C. elevator* Dyar and Knab. Fig. 33, *C. equinoxialis* Floch and Abonnenc. Fig. 34, *C. erraticus* (Dyar and Knab). Fig. 35, *C. evansae* Root. Fig. 36, *C. flabellifer* Komp.

38
IDOTTUS
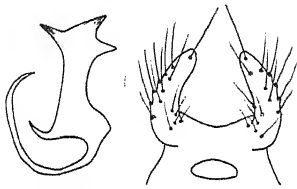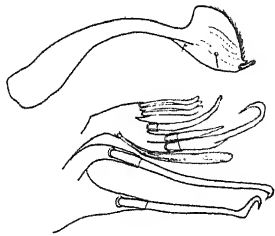
37 HESITATOR
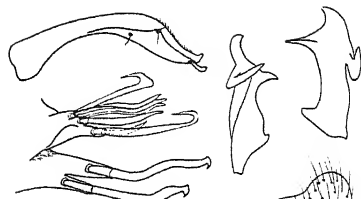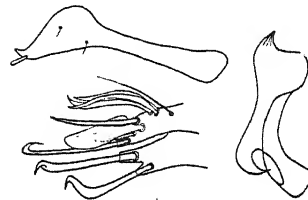
39
IMPLICATUS
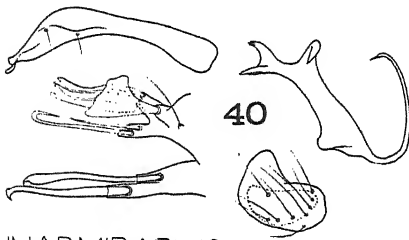
40
INADMIRABILIS

41
INHIBITATOR
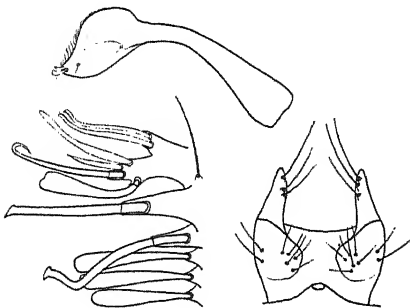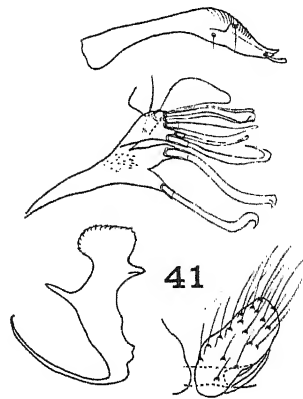
42 INNOVATOR

Male genitalia of *Culex*. Fig. 37, *C. hesitator* Dyar and Knab. Fig. 38, *C. idottus* Dyar. Fig. 39, *C. implicatus* Senevet and Abonnenc. Fig. 40, *C. inadmirabilis* Dyar. Fig. 41, *C. inhibitator* Dyar and Knab. Fig. 42, *C. innovator* Evans.
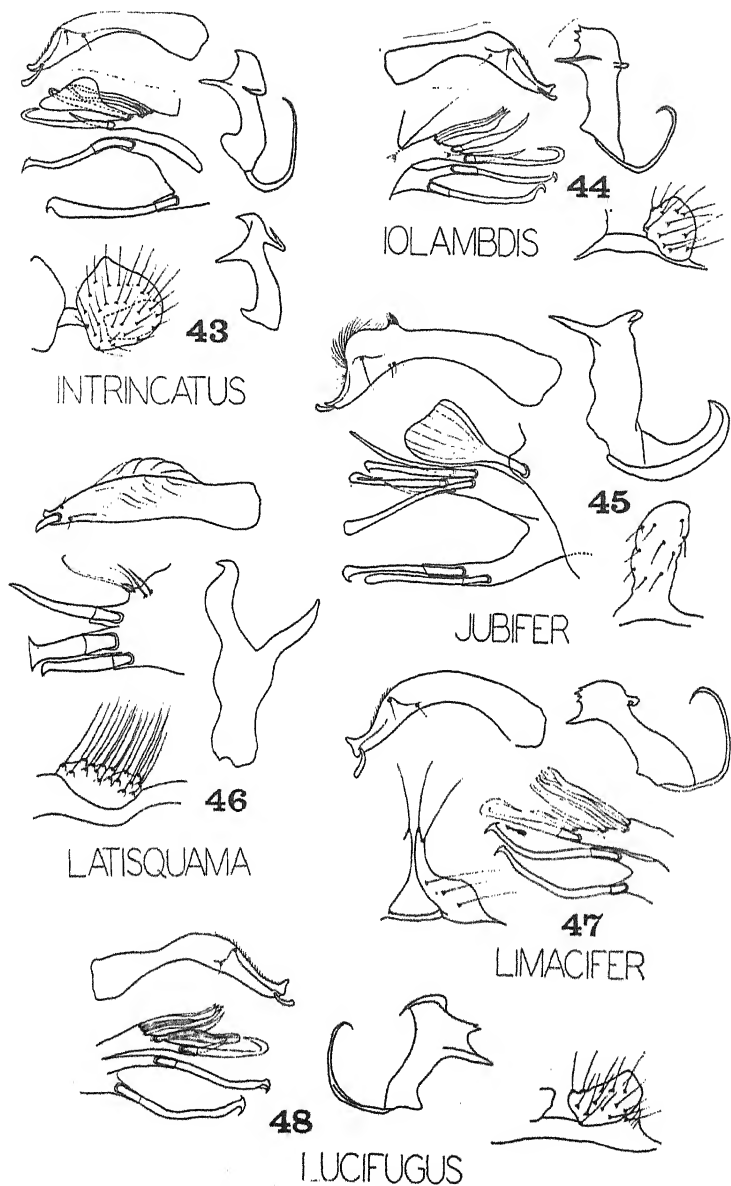
Male genitalia of *Culex*. Fig. 43, *C. intrincatus* Brèthes. Fig. 44, *C. iolambdis* Dyar. Fig. 45, *C. jubifer* Komp and Brown. Fig. 46, *C. latisquama* (Coquillett). Fig. 47, *C. limacifer* Komp. Fig. 48, *C. lucifugus* Komp.

49 MADININENSIS

51 MAXINOCCA

50 MARONIENSIS

52 MENYTES

53 MULRENNANI

54 SP. A
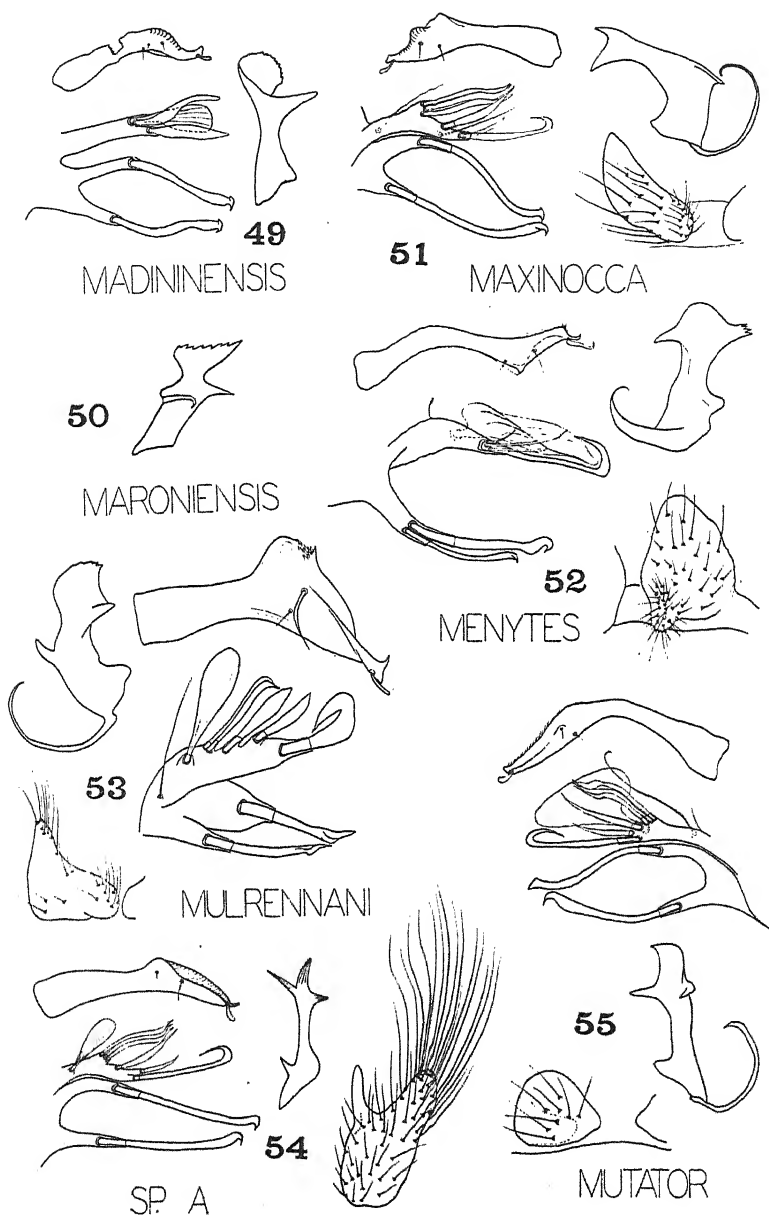
55 MUTATOR

Male genitalia of *Culex*.   Fig. 49, *C. madininensis* Senevet.   Fig. 50, *C. maroniensis* Bonne-Wepster and Bonne.   Fig. 51, *C. maxinocca* Dyar.   Fig. 52, *C. menytes* Dyar.   Fig. 53, *C. mulrennani* Basham.   Fig. 54, MS. Species A.   Fig. 55, *C. mutator* Dyar and Knab.
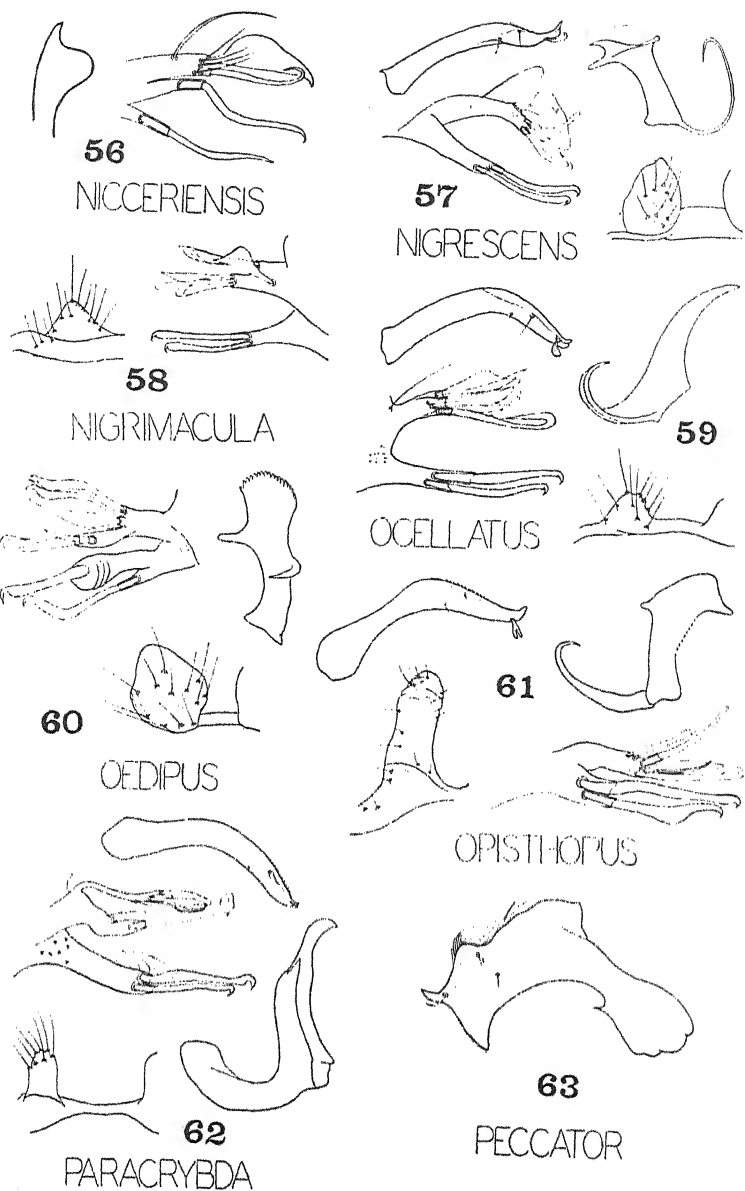
Male genitalia of *Culex*. Fig. 56, *C. nicceriensis* Bonne-Wepster and Bonne. Fig. 57, *C. nigrescens* (Theobald). Fig. 58, *C. nigrimacula* Lane and Whitman. Fig. 59, *C. ocellatus* Theobald. Fig. 60, *C. oedipus* Root. Fig. 61, *C. opisthopus* Komp. Fig. 62, *C. paracrybda* Komp. Fig. 63, *C. peccator* Dyar and Knab.
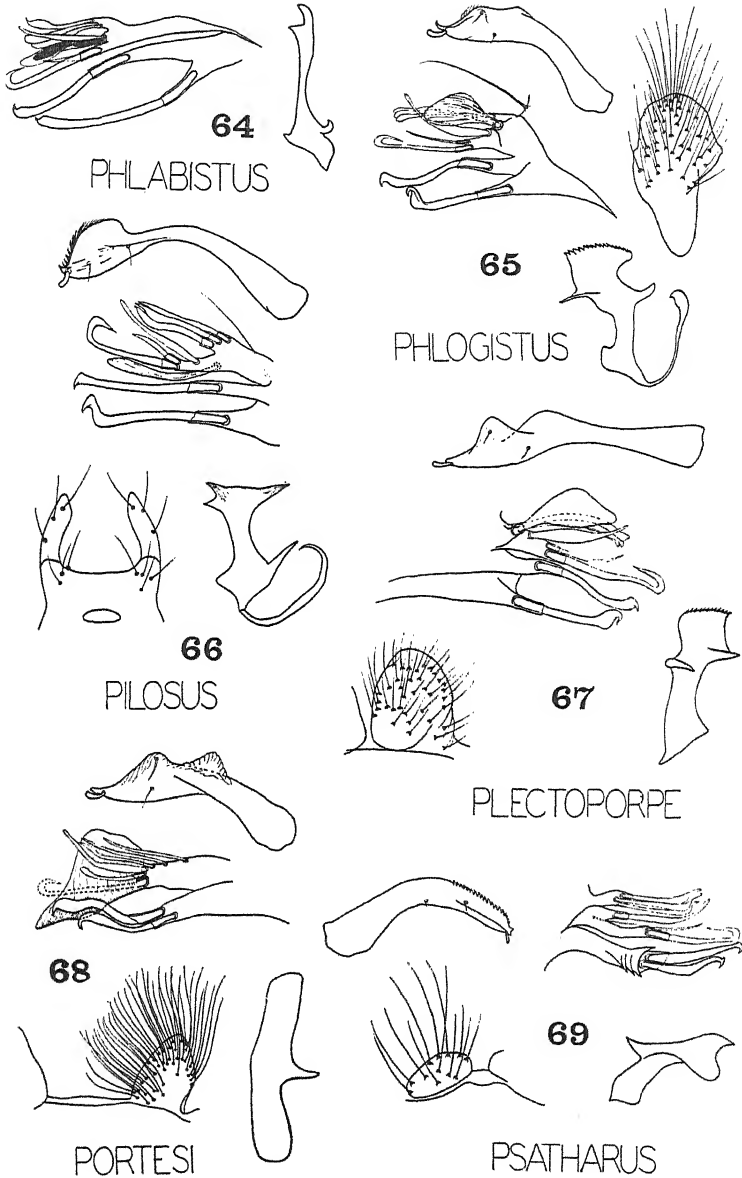
Male genitalia of *Culex*. Fig. 64, *C. phlabistus* Dyar. Fig. 65, *C. phlogistus* Dyar. Fig. 66, *C. pilosus* Dyar and Knab. Fig. 67, *C. plectoporpe* Root. Fig. 68, *C. portesi* Senevet and Abonnenc. Fig. 69, *C. psatharus* Dyar.
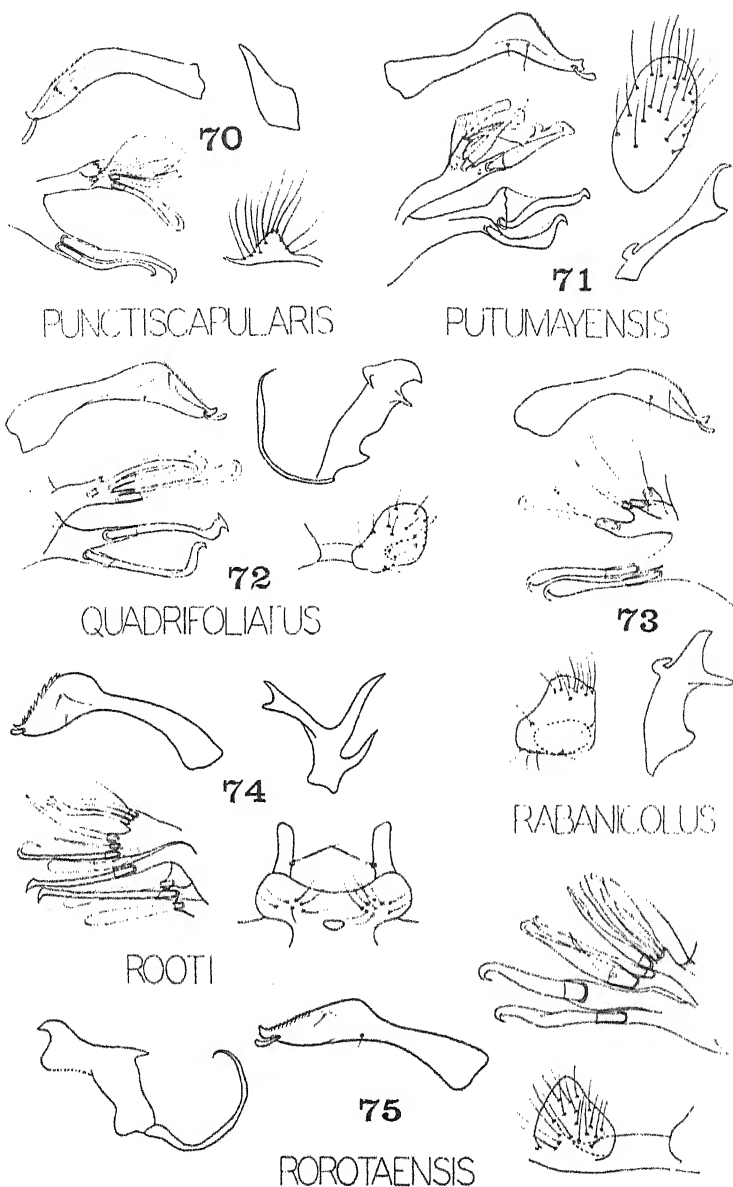
Male genitalia of *Culex*. Fig. 70, *C. punctiscapularis* Floch and Abonnenc. Fig. 71, *C. putumayensis* Matheson. Fig. 72, *C. quadrifoliatus* Komp. Fig. 73, *C. rabanicolus* Floch and Abonnenc. Fig. 74, *C. rooti* Rozeboom. Fig. 75, *C. rorotaensis* Floch and Abonnenc.

76 SARAMACCENSIS

78 SPISSIPES

77 SERRATIMARGE

79 SURSUMPTOR

80 TAENIOPUS
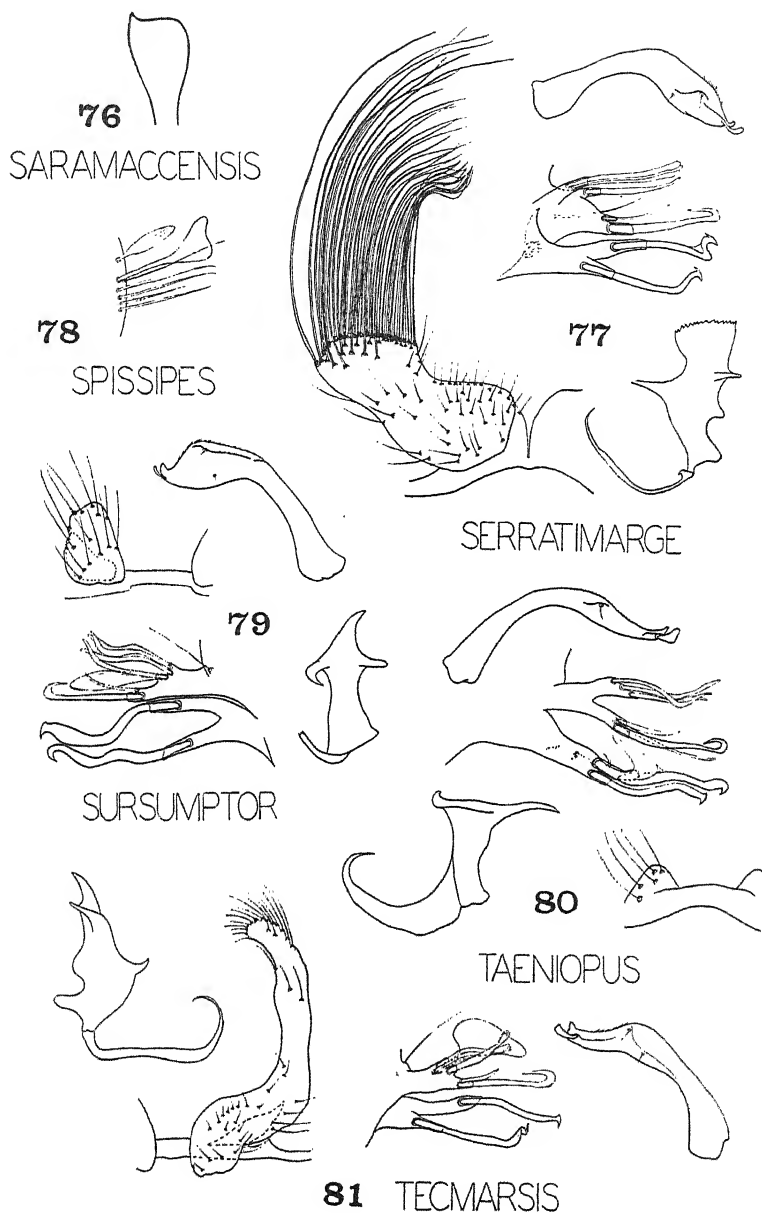
81 TECMARSIS

Male genitalia of *Culex*. Fig. 76, *C. saramaccensis* Bonne-Wepster and Bonne. Fig. 77, *C. serratimarge* Root. Fig. 78, *C. spissipes* (Theobald). Fig. 79, *C. sursumptor* Dyar. Fig. 80, *C. taeniopus* Dyar and Knab. Fig. 81, C. *tecmarsis* Dyar.
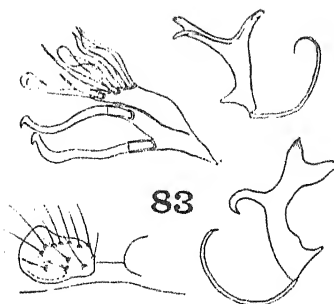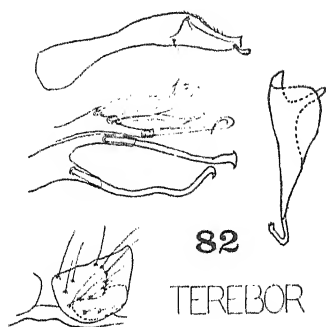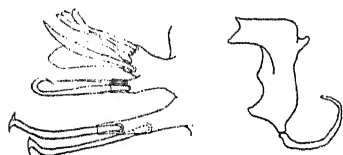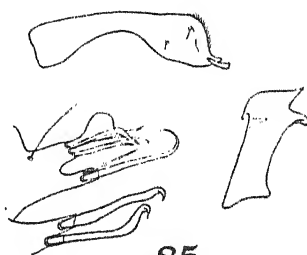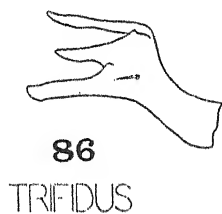
Male genitalia of *Culex*.   Fig. 82, *C. terebor* Dyar.   Fig. 83, *C. theobaldi* (Lutz).
Fig. 84, *C. thomasi* Evans.   Fig. 85, *C. tournieri* Senevet and Abonnenc.   Fig. 86,
C. trifidus Dyar.   Fig. 87, *C. unicornis* Root.
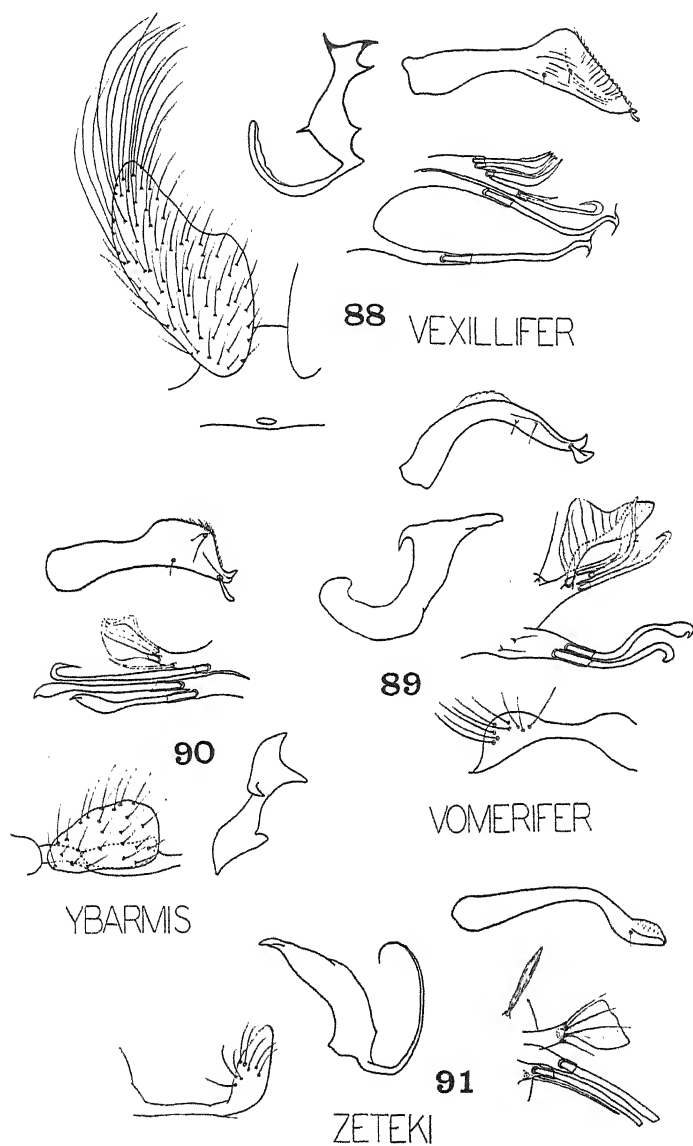
Male genitalia of *Culex*. Fig. 88, *C. vexillifer* Komp. Fig. 89, *C. vomerifer* Komp. Fig. 90, *C. ybarmis* Dyar. Fig. 91, *C. zeteki* Dyar.

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SUMMARY TABLES OF BIOLOGICAL TESTS, VOL. 1, NOS. 1 AND 2.

121 pages. Mimeographed. Chemical-Biological Coordination Center, National Research Council.

These tables contain the results of tests performed on compounds submitted to the Center for preliminary screening to determine their biological effects on a series of laboratory animals and plants. These publications make available in summary form the results of biological tests reported by screening agencies cooperating in this program. The tables are arranged according to the type of test employed followed by a description of the test technique involved. Within the type of test the chemicals are listed alphabetically by the Chemical Abstracts System of Nomenclature followed by the structural formula and a brief statement of the test results. Reports on Antibacterial, Arachnidicide, Fungicide, Insecticide, Plant Growth Regulator, Insect and Rat Repellency, Rodenticide, Mammalian Toxicity, Antimalarial, Brucellosis, Cancer, Snail Control and Rickettsia are included in these issues. These tables are available without cost; requests should be addressed to National Research Council, Chemical-Biological Coordination Center, Washington 25, D. C.

NEW NORTH AMERICAN TABANIDAE

(Diptera)

Part II. Tabanidae

CORNELIUS B. PHILIP

Hamilton, Montana

New species of Pangoniinae and new information on specific synonymy, distribution, and location of types of Nearctic Tabanidae are described and discussed in collateral papers (Philip, 1949a, b). The holotypes and allotypes of the following additional species are in the collection of the author unless otherwise indicated.

Tabanus boharti n. sp.

A medium-sized, blackish-gray species with brownish suffusion of the abdomen overlain by three rows of prominent pale triangles, beneath which the integumental infuscation is confined to tergite 1 baso-laterally, on tergite 2 to an elongated central spot, and on tergite 3 to a smaller meso-basal spot. Wings, including costal cell, hyaline; veins chocolate brown, no spur; subepaulets hairy.

Holotype ♀, 15 mm. Eyes bare; two narrow green bands on a purple ground (relaxed); no ocelligerous tubercle. Front slightly widened above, 1 : 4, grayish pollinose, except for two small brownish spots and a brownish band across the middle; sparsely black-pilose; median callus small, subovoid, blackish, separated from the basal callosity which is piceous with brownish tinges and rounded corners below, and irregularly emarginate above, not quite touching the eye margins (fig. 1B). Subcallus dull yellow-pollinose, the pollen extending onto the upper area of each cheek; no lateral hairs on subcallus. Face, genae (except upper angles), coxae, and pleura pruinose. Palpi deep yellowish, stout basally, apically more acuminate and drawn out than in *abditus*, with appressed black and white hairs in about equal numbers. Antennae dark brown, blackish beyond the basal angle of the plate; scape robust but not hood-like over the pedicel as in *abditus;* plate about as tall as long, the dorsal angle prominent, but with little excision beyond; annuli short and thick, shorter than length of plate.

Thoracic gray and black lines prominent, with sparse blackish and appressed copper hairs on the dorsum; scutellum concolorous, blackish. Pleura and coxae whitish-pruinose and pilose. Legs dark with gray pollinosity, the basal half of the first and all but the tips of the hind two pairs of tibiae pallid. Hind-tibial fringe with black hairs on the distal half, predominantly whitish basally.

Abdomen dark gray with three rows of prominent pale triangles, overlying suggestions of reddish laterally on tergite 2; it is less brownish than in *pruinosus*, with the sublateral dashes more prominent, those on

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tergite 2 touching the hind borders when viewed from behind, but the others well separated.   The venter brownish with white hairs, the middle third with a broad, longitudinal, parallel-sided band of blackish hairs and dark brown pollinosity its full length.

White House Canyon, Santa Rita Mts., Ariz., 31 May, 1946. R. M. Bohart.   It is a pleasure to name the species for this energetic collector who has taken much interesting material in the field.

Three paratype females in close agreement from Arizona: 1, Tucson, 29 July, 1914, B. R. Coad, Bishopp No. 3535; 2, Mud Springs, Santa Catalinas, 17 to 20 July, 1916, about 5000 feet.   In the collections of the United States National Museum, American Museum of Natural History, and the author.

This species is undoubtedly the Nearctic form of *pruinosus*, recorded by Stone (1938) from Utah and Arizona, and is also probably what Townsend (1892) referred to as "*T. vivax*" from the Grand Canyon in consideration of the eye colors, though he gives the length as only 12 mm.
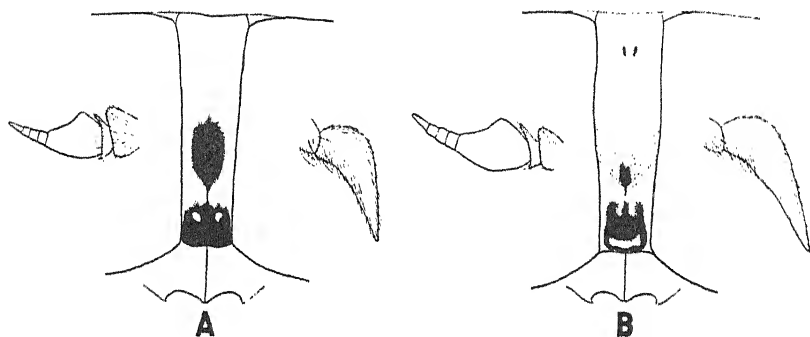
FIG. 1.   Front, antenna, and palpus of: A. *Tabanus abditus* Philip ♀;
B. *T. boharti* n. sp. ♀.

In true *pruinosus* Bigot from Mexico (syn. *limpidipennis* Hine, Guatemala), the antennal scapes are equally robust but the plates are a little longer and more excised (fig. 2C), the legs are concolorous, reddish, the abdomen is more uniformly brownish with the sublateral spots smaller, rounded and more obviously isolated from both borders of the tergites, the mid-ventral band is narrower and less contrasting, and the body is more robust and larger.   In Stone's key to females, *boharti* would key out to *fairchildi*, which it rather closely resembles, but may be distinguished by separation of the frontal callosities, its broader, less excised antennal plate, more sharply acuminate palpi, browner abdomen with more prominent sublateral dashes, and the dark mid-ventral longitudinal band.   The geographic distribution of the two is markedly different also.   There is a superficial resemblance to *T. abditus* but the latter has a hood-like scape taller than the plate (fig. 1A), paler callosity touching the eye margins, the dark abdominal maculations cinereus rather than brownish, with more prominent pale incisures, and no contrasting mid-ventral dark band.

Tabanus abditus Philip

Neallotype ♂, 15 mm.   Like the female and easily associated, the lateral brownish ground color more pronounced on the second to fourth tergites; the pale triangles on these tergites large (excepting the middorsal one on the second which is evanescent) and connected narrowly across the posterior incisures.

Head not markedly larger than that of the female.   Eyes bare, the upper facets scarcely enlarged.   Occipital tubercle gray-pollinose, about on level with eyes, a few gray and black hairs posteriorly.   Frontal triangle gray-pollinose, subshiny brown in the apex.   Palpi almost entirely white haired, the terminal segments swollen, little over a third longer than thick, with very slight, downward pointed nipples. Scutellum dark, grayish-pollinose.   Fore-tarsal claws subequal.

One specimen, Young, Ariz., 30 May, 1943, F. H. Parker.
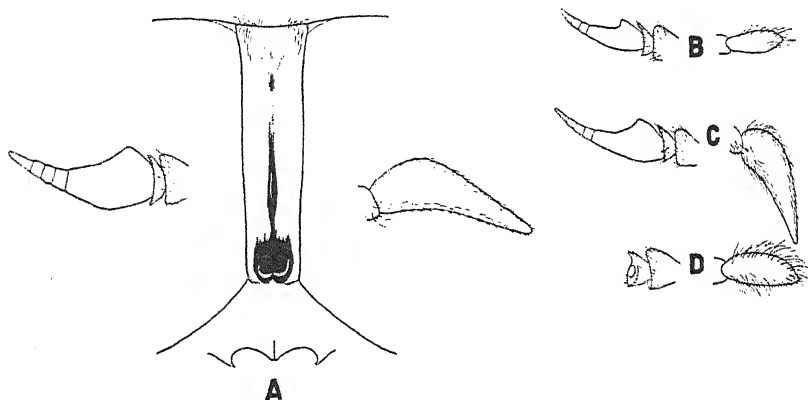
FIG. 2.   A. Front, antenna, and palpus of *Tabanus kesseli* n. sp. ♀. B. Antenna and palpus of *T.* n. sp. ♂ (described in Part III to follow). C. Same of *T. pruinosus* Bigot ♀.   D. Same of *T. quirinus* n. sp. ♂.

T. dorsifer Walk., which this somewhat resembles, has a bicolored scutellum, broader, more contrasting middorsal triangles on tergites 1, 3, and 4, and the sublateral triangles on 3 and 4 much less pronounced. The second palpal segments are less swollen, with more black hairs evident.   The area of enlarged eye facets is also more pronounced. In *fairchildi* Stone, the abdomen is grayer with a more pronounced middorsal triangle almost crossing tergite 2 and the palpi are more slender.   The male of *T. abditus* would run to couplet 43 in Stone's (1938) key to males where it would separate out with the combination of gray pleural hair and undifferentiated eye facets.

Tabanus kesseli n. sp.

A large, essentially blackish western species with subhyaline wings, related to *aegrotus* O. S., but averaging smaller in size, the median callus linear, a definite cloud on the base of R_4, and (in well-preserved specimens) a middorsal row of small, easily rubbed, pale triangles on the abdomen.

Holotype ♀, 19 mm.   Eyes bare, black, unbanded (relaxed).   Front very slightly narrowed below, 1 : 4.5 (Fig. 2A); brown-pollinose and pilose with a few black hairs intermixed, and the entire ocular margins to the vertex with narrow gray pollinosity.   Basal callosity flat, subquadrate with distinct upper angles, the median callosity narrowly connected, and broadened above, but not as much as in typical *aegrotus*, terminating a little over half way to the vertex.   Subcallus less thinly brown-pollinose than most *aegrotus*, the face and cheeks concolorous with dark pile.   Antennae black with black hairs basally, scape a little less swollen disto-dorsally, and plate with a less prominent dorso-basal tooth than in *aegrotus* (Stone, 1938, Fig. 37A), the latter a little longer than broad, and than the annuli, with reddish tinges on the inferior basal portion.   Palpi rather sharply attenuated, coal black with appressed black hairs (the integument beneath is more brownish in typical *aegrotus*).

Thorax and abdomen subshiny, black with black hairs, some brownish tinges on the former and restricted gray pollinosity anteriorly, no evident lines.   A few pale hairs at the base of the wings, and a row of small contrasting middorsal pale triangles on tergites 1 to 5, but not with the usual underlying pale pollinosity of some other species.   Wings with brownish tinges basally and costally, and the cloud on the fork of R_{4+5} more intense than in most *aegrotus*.   Legs black with black vestiture.

West Fork, Ravalli Co., Mont., 25 July, 1935, C. B. Philip.

Allotype ♂, 17 mm.   Body and legs more mahogany-brown than in the holotype; otherwise in close agreement except for the usual sexual differences, and readily associated.   Head large, subhemispherical, eyes bare, the area of enlarged facets sharply demarcated in the upper two-thirds.   Apical palpal segment hardly twice as long as thick.   Fore tibiae distinctly paler on the basal third.   Some sparse, coppery, appressed hairs on the notum among the brown pile, and some inconspicuous pale hairs above the alulae and outer margins of the scutellum and along the outer incisures of tergites and sternites 2 and 3.   The pale patch on tergite 1 prominent, but the other middorsal triangles worn and represented by only a few pale hairs.   The 'fork" and all basal veins distinctly margined with brown.

Departure Bay, B. C., 4 VIII 33.   Through courtesy of the late Eric Hearle who had justifiably labeled it "*Tabanus aegrotus*."

Paratypes, 17.5–19 mm.   CALIFORNIA--♂, Fairfax, 11 May, 1919, E. P. VanDuzee; 2♂, Shasta Sprgs., 15, 16 June, 1920, C. L. Fox; ♂, ♀, Berkeley, 24 Aug.–3 Sept., 1921, E. C. VanDyke; ♀, Mariposa, 13 June, 1938, Carl T. Sierra; ♂, Yosemite, alt. 3880–4000 ft., 13 June, 1938, Carl T. Sierra; ♀, Feather River, Butte Co., Hwy. 24, 14 June, 1934, M. Cazier, T. Aitken; ♀, Marin Co., 3 Aug., 1929, R. H. Beamer; ♀, Mill Valley, Marin Co., 21 June, 1948, Tommy Leech; 2♀, Santa Cruz, July, 1904, F. X. Williams; ♀, near Callahans, Siskiyou Co., 13 June, 1934, E. C. VanDyke; ♀, Mokel Hill, 11 July, 1910, F. E. Blaisdell; ♀, Cypress Ridge, Mariposa Co., 19 June, 1921, C. L. Fox; ♀, Castella, 1 Aug., 1918, J. A. Kusche; 2♀, Vacaville, 8 July, 1948, A. T. McClay; ♀, Nevada City, 24 June, 1947, E. L. Kessel; ♀, Giant Forest, 6400–7000 ft., 9–13 Aug., 1927, J. C. Bradley; ♂, San Jacinto Mts., 21 July, 1929, Paul W. Oman; ♂, David, 11 June, 1936, J. J.

duBois; 3♂, Mt. Wilson, 5 June, 1909; ♀, S. Gabriel Mts. near Pasadena, 9 June, 1929, Brooklyn Mus. Coll.; ♀, Eldorado, "6.20.0"; ♀, "Cal., Baron," (?); ♂, Monte Rio, 11 July, 1929, F. H. Wymore, R. M. Bohart, G. E. Bohart; 2♀, Hastings Reservation, Robles del Rio, 16 July and 2 Oct., 1949, J. Linsdale.   OREGON—♀, Hugo, 1 July, 1925, G. R. McGinnis; ♀, Mary's Peak; ♀, Portland, "7-12—Cook"; ♀, Forest Grove, 4 July, 1920, Max Reeher; ♀, Mt. Hood, H. K. Morrison.   WASHINGTON—♀, Green River Gorge, 6 Aug., 1932, Wm. W. Baker; ♀, Hoodsport, 7 July, 1920, H. G. Dyar; ♀, Blue Mts., 15 July, 1896, C. V. Piper; ♂, Waldron Is., 1 July, 1909, W. Mann; ♀, Tablerock Mt., 1 Oct., 1948, H. F. Bryan.   BRITISH COLUMBIA— 4♂, 3♀, Departure Bay, 2, 4, 5 July, 1933, 7 Aug., 1908, July, 1909; 2♂, ♀, Robson (Warfield), 8 July, 1943, 6 July, 1946, H. R. Foxlee; 2♂, 4♀, Lillooet, 3 Aug., 1917, 21 July, 1939, 1942, A. W. A. Phair; ♂, 2♀, Pender Harbor, 7 July, 1928, G. R. Hopping; ♀, Fish Lake, 1 Aug., 1928.   IDAHO—♀, Franklin, 28 June, 1931, J. S. Sanford. MONTANA—♀, Mill Creek, Ravalli Co., 25–30 July, 1932, Byrne Thrailkill; ♀, same data, as holotype.   NEVADA—♀, Risu Canyon, 4 July, 1917, on horse, E. M. Dobbs, 7502.   UTAH—♂, Logan, 14 April, 1948, B. B. Houck; ♀, Logan, July, 1947, M. Nielson; ♀, Logan Canyon, 5700 ft., 26 July, 1915; ♀, (same), 4–18 Aug., 1912, H. R. Hagen; ♀, Logan, 9 July, 1942, E. Stoddard; ♀, Logan, 8 Aug., 1938, G. F. Knowlton; ♀, Holden, 7 July, 1943, Knowlton and Telford, "Dam. potatoes"; ♀, Logan, 8 July, 1940, Knowlton and Stains, "at light"; ♀, Beaver Creek Hills, Beaver Co., Brooklyn Mus. Coll., 1929.

Paratypes in collections of the U. S. National Museum, Museum of Comparative Zoology, American Museum of Natural History, California Academy of Sciences, Canadian National Collection, Livestock Insect Laboratory, Kamloops, B. C., Utah State Agricultural College, University of Kansas, State College of Washington, L. L. Pechuman, and the author.

Paratype females in essential agreement with the holotype but the middorsal abdominal triangles in various states of wear to complete absence of all but tergite 1; the pale tuft on the latter below the scutellum is evident in all of both sexes but one, and never seen in typical *T. aegrotus.*

Three males and seven females of the typical form are before me from California, Oregon, Washington, and Idaho (plus a considerable series seen at U.S.N.M., including B.C. in addition), only three of which are below 21 mm. in length, and all the females agree in the more broadly tapered median callosity, more dorsally swollen scapes, very faint or absent cloud on the bifurcation, and no vestige of pale hairs even on tergite 1.   It was the male of this typical form that was described by me in 1936 and it differs from *kesseli* in having the upper area of eye facets hardly differentiated, the occipital tubercle with definite indication of ocelli, more swollen palpi, fore tibiae unicolorous and no pale hairs at locations indicated for *kesseli.*   Labels indicate that at least once in each of the three Pacific Coast states, females of both species have been taken on simultaneous dates, which in part accounts for the confusion of the two until now.

Named in honor of Dr. E. L. Kessel whose almost perfect specimen initiated eventual separation of this species.

Tabanus quirinus n. sp.

A large, warm chocolate to mahogany brown fly with bare eyes, no differentiation of facets above, hyaline wings with costal cells and margins of basal veins brown and an almost imperceptible cloud at the furcation, hairy subepaulets, and robust build with the abdomen peculiarly tapered like *T. recedens.*

Holotype, ♀, 21 mm. Head rather flat because of uniform eye faceting; eyes bare, colors (relaxed) with lower border and a central band purple, the upper area and a submedian band greenish, the occipital tubercle small and sunken; face and cheeks brownish-pollinose and pilose; frontal triangle flat, dull brown-pollinose and crossed diagonally downward to the outer bases of the antennae by two peculiarly prominent furrows; scape and pedical brown with dark hairs, not enlarged (fig. 2D, third segments missing); palpi reddish-brown with darker hairs, the apical joints a little thicker than the basal ones and a little less than twice the thickness in length, tapering distally to a blunt point; tongue small, labellae fleshy.

Thorax dark, subshiny chocolate brown, the lines scarcely perceptible anteriorly; pile brown on the disc, darker on the antealar tubercles and pleura; scutellum concolorous, a little more reddish on the margin. Legs dark brown, concolorous, hind tibiae not fringed but with longer pile outwardly. Outer fore-tarsal claws slightly elongated. Cell R₅ wide open, no spur.

Abdomen reddish brown, concolorous above and below, covered with rather heavy blackish brown hair, densest behind the scutellum, crossing the second and onto part of the third tergites. The incisures, especially of the sternites, narrowly pale-pollinose, with small, indefinite expansions mesally on the hind margins of tergites 2 to 5 but not accentuated by pale hairs to form triangles.

Port St. Joe, Florida, 7 April, 1945, H. T. Spieth. In the American Museum of Natural History. A letter from the collector states "the fly was taken on the outskirts of town near the Municipal Auditorium in a scrub pine area in which cattle graze."

This is an enigmatic species without apparent affinities to any known Nearctic tabanids and the missing third antennal segments are unfortunate since the specimen is otherwise exceptionally well preserved.

Hybomitra difficilis (Wiedemann)

The type *Tabanus difficilis* Wied. was not located for Stone (1938), but has since been found by Dr. Max Beier and loaned to the writer for study. It proves to be the same as *Hybomitra carolinensis* of authors, not Macquart. As indicated elsewhere (Philip, 1949a), the latter actually is the prior name for *Hamatabanus scitus* Wlk. (*cerastes* O. S.).

In the belief that *H. carolinensis* of authors required a name, the writer had provided a new one in manuscript, but the proper name for this well-known and rather variable species now becomes *Hybomitra difficilis* (Wied.). The type has the most noticeably reddish abdomen, yellow frontal calli and low, transverse basal callosity yet seen by me. There is only a faint, dark shadow beneath the scutellum on the abdomen and all the coxae are reddish. The front is convergent below, compared to some specimens which appear almost parallel. No other localities

are given on the labels than "Am. bor.," and in addition to the label "difficilis Wied. type," there is a label "Archiplatius difficilis Wd., det. Krober 1929." In addition to the distribution catalogued, the species has been seen from D. C. and Tenn.

T. patulus Wlk., formerly listed by the writer and Stone as a synonym of *carolinensis*, proves to be the prior name for *H. oklahomensis* Stone.

On suggestion by Dr. Stone that this discovery might preoccupy Kroeber's *Therioplectes difficilis* from New Zealand, the writer borrowed the type from the Berlin Museum through courtesy of Dr. Peus and found the subepaulets to be without black, bristly hairs as on the costa though there is a fine brown pubescence present. This with other characters would appear to place it in the genus *Cydistomyia* as recharacterized by Oldroyd. There is a remarkably long, decurved, upright row of hairs around the ocular rim, and a few pale hairs on each side of the frontal triangle. The occipital tubercle is relatively low, entirely dull pollinose, brown anteriorly, grayish behind. The eyes are prominently hairy. Change of name is thus not warranted.

Leucotabanus annulatus (Say)

Two early males of this in the Vienna Museum labelled "Pennsylv." and "*argenteus* Coll. Wiedem." provide a new state record for this species (though this state may have had entirely different boundaries in the early days when Say sent specimens to Wiedemann, as called to my attention by Dr. Bequaert). The latter name must have been a manuscript name that was never published. There is another *Tabanus argenteus* Surcouf, 1907, from West Africa.

Hybomitra hinei (Johnson)

This species has three ocelli in the female and one in the male at the vertex as distinct as in *H. cincta* (Fabr.), genotype of *Dasyommia* End. (=*Hybomitra* End.). A series of nearly three dozen specimens of subsp. *wrighti* (Whit.) including two males taken by R. W. Dawson in April, 1948, at Lake Placid, Fla., further confirms Bequaert's subjugation of this to *hinei*. There is some variation in the extent of red on the sides of the abdomen, and occasionally on the extreme base of the antennal plate, but in none as extensively as in the northern *hinei*. Bequaert mentions a dark N. Y. female, and the writer has a male from that state that has the median black on tergites 2 and 3 wider than one of the above Lake Placid series. Since this sex of *wrighti* has not been reported, it is herewith described.

Neallotype ♂, 12 mm. Resembles more closely the northern males of *hinei* than do the respective females of the two forms. The brown pile of the eyes and yellowish pile of the dorsum and sides of the thorax noticeably shorter and less dense. Scape of antennae blackish, dark brownish below, plate reddish at the extreme base. Palpi coal-black, terminal segment more slender and less bluntly rounded at the end (this varies, however, in northern males seen). Distribution of red on the sides of tergites 1 to 3 about the same, much more extensive and continuous than in the females of *wrighti*. Wings as in the females, darker than northern males.

Biological Station, Lake Placid, Fla., 17 April, 1948, R. W. Dawson. A series of *wrighti* females taken at the same time.

The male from New York has close resemblance, except that the antennae are a little redder basally, the palpi are brown and the second segments are thicker, shorter, and blunter terminally, and the reddish a little more *reduced* on the sides of the abdomen.

Whitneyomyia beatifica subsp. atricorpus nov.

This is the form which Stone (1938) considered as possibly deserving distinct varietal rank pending appearance of a larger series of typical specimens with white hair laterally on the abdomen. Actually, the writer considers this as only a possibly physiological melanistic variant, but for taxonomic validity, it is here given subspecific rank. The preoccupied *T. ater* Palisot de Beauvois and *T. lugubris* Macquart seem to be synonyms of this form, while *Snowiellus stygius* Enderlein is synonymous with the typical form.

Holotype, ♀, 14.5 mm. Like typical *beatifica* but differs in that the body vesture is entirely blackish or dark brown. It lacks the contrasting lateral, pale-haired, longitudinal bands on the abdomen. The antennae and palpi are entirely blackish.

Alachua Co., Fla., 9 March, 1930. A gift of the late J. S. Hine.

A paratype female in close agreement is in the American Museum of Natural History, Sarasota, Fla., 2 April, 1938. F. E. Lutz, collector.

This is obviously another early species on the wing in Florida. Dr. R. W. Dawson collected 55 of the previously uncommon typical form with abdomen gray haired laterally, in less than an hour at Apalachicola, Fla., 29 April, 1948. None were of this all blackish variant. He also took 7 *T. bishoppi*, 50 *H. hinei* var. *wrighti*, the rare *T. birdei* and *T. endymion* during this early collecting in an otherwise thoroughly collected state later in the summertime. Since another species described above, *T. quirinus*, comes from Florida in early April, the productive results of early Gulf Coast collecting of Tabanidae are emphasized (*H. annularis* Hine, *H. sexfasciata* Stone, *T. kisliuki* Stone, and *A. geropogon* Philip are other early, little-known southern species).

Acknowledgments will be made in Part III to follow.

SUMMARY

Described as new are: *Tabanus boharti* n. sp. (holotype ♀, from Arizona); *T. kesseli* n. sp. (holotype ♀, from Montana, and ♂); and *Whitneyomyia beatifica* subsp. *atricorpus* nov. (holotype ♀, from Florida). The males of *T. abditus* Phil. and of *H. hinei* subsp. *wrighti* Whit. are described for the first time. *T. difficilis* Wied. is shown to be the prior name for *Hybomitra carolinensis* of authors, not Macquart.

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BIOLOGICAL AND CROSSBREEDING STUDIES ON AEDES HEBRIDEUS AND AEDES PERNOTATUS

(Diptera, Culicidae)[1]

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The widespread distribution of members of the *"scutellaris"* group of mosquitoes (subgenus *Stegomyia*, genus *Aedes*) and their associated similarities in breeding preferences has been emphasized by Farner and Bohart (1945). The combined geographic range as reported by these two authors extends from the Marquesas Islands and the Tuamotu Archipelago in eastern Polynesia westward to the Andaman Islands and from the New Hebrides northward to the Marianas and the Philippines.

The biology of the recorded species is markedly similar in that larvae and pupae are commonly collected in water held in artificial containers: coconut shells, coconut husks, tree holes, water jugs, cacao pods, tin cans, tire casings, tarpaulins, leaf axils, etc.

Their biting habits are well known for they are troublesome and annoying, and the females bear a medical importance shown in records of specific members transmitting filariasis and dengue in endemic areas of the Pacific Ocean.

The many forms of the group as recorded from 1932 were designated as varieties of *"scutellaris."* Systematic group work conducted in the United States by Farner and Bohart (1945) and Stone and Bohart (1944) indicates that members of the *"scutellaris"* complex, to which *Aedes hebrideus* and *Aedes pernotatus* belong, should be regarded as separate species.

In view of the gross similarities of these two species, studies on the male genitalia indicated each to have distinct hypopygial features. On this basis these authors have raised the two forms to specific status.

Woodhill (1949) conducted experimental crossing on *scutellaris* (*hebrideus*) from Lae, New Guinea, and *katherinensis* from Katherine,

Northern Territory of Australia. He concluded that if *scutellaris* and *katherinensis* were present in the same area they would interbreed, producing populations with all degrees of intergradation between the two forms. In view of the sterile reciprocal cross, however, he regards *scutellaris* and *katherinensis* as subspecies.

On Espiritu Santo in the New Hebrides, two apparently closely related species, *Aedes hebrideus* and *Aedes pernotatus*, occur together. Although no intermediate adult forms have been recovered in nature, an attempt was made to determine the ease with which crossbreeding would take place.

The procedures used in these experiments were similar in basic design to those used by Hoang-Tich-Try (1939) and Toumanoff (1939) in their crossbreeding studies on *Aedes aegypti* and *A. albopictus*. Different geographical forms were not utilized as in their experiments for only two dominant species as found on Espiritu Santo were maintained as colonies. Attempts were made to develop island strains and to note constant morphological differences in the progeny produced in these studies.

Colonies were established in an outdoor insectary and biological studies conducted on the two separate species. Crossbreeding experiments were carried out with individually reared specimens to determine their position taxonomically and the ease with which these apparently closely related forms will interbreed, transmit disease, and produce viable offspring.

AEDES (STEGOMYIA) HEBRIDEUS EDWARDS (FIGS 2 AND 4)

The synonymy of this species and the collection records have been well covered by Farner and Bohart (1944).

Although Daggy (1944) suggested this species as a probable vector of dengue in the New Hebrides, more complete epidemiological evidence (Perry, 1948) gathered over a two-year period on all the major island military bases in the New Hebrides-Solomon chain, would relegate this species to a minor if not negative role as a vector of dengue in nature. Mackerras (1946) has demonstrated the island strain of *hebrideus* found in New Guinea as the responsible transmitting agent of "jungle" dengue fever in that area. MacQueen and the author have indicated that island strains of this species may vary in their ability to transmit dengue.

Byrd and St. Amant reported a 2.9 percent infection of *Wuchereria bancrofti* in dissection records maintained on 414 specimens on Espiritu Santo. Of this group, there were no infective stage larvae and no developing filaria beyond the 4th day of age. Indications are that this species is not important in the transmission of filariasis in the New Hebrides, in contrast to high infectivity rates for *pseudoscutellaris* from the Fiji, Wallis, Ellice, Samoa, Cook and Society Islands (Byrd *et al.*, 1945).

Of the two forms, *hebrideus* is by far the most active biologically.

Present studies conducted on eight separate females indicate high production of ova and relatively short periods of aquatic development. The females bite humans throughout the day from sunrise to sunset and are particularly active on cloudy, rainy days. Because of their

tenth abdominal hair usually plumose to base.

apical spines with two to four plumose branches. (usually four)

(a)   TERMINAL AND FIRST ABDOMINAL SEGMENTS OF PUPA.

(b)   HEAD CAPSULE OF LARVA.

complete sclerotic plate

(c)   TERMINAL SEGMENTS OF FOURTH INSTAR LARVA.
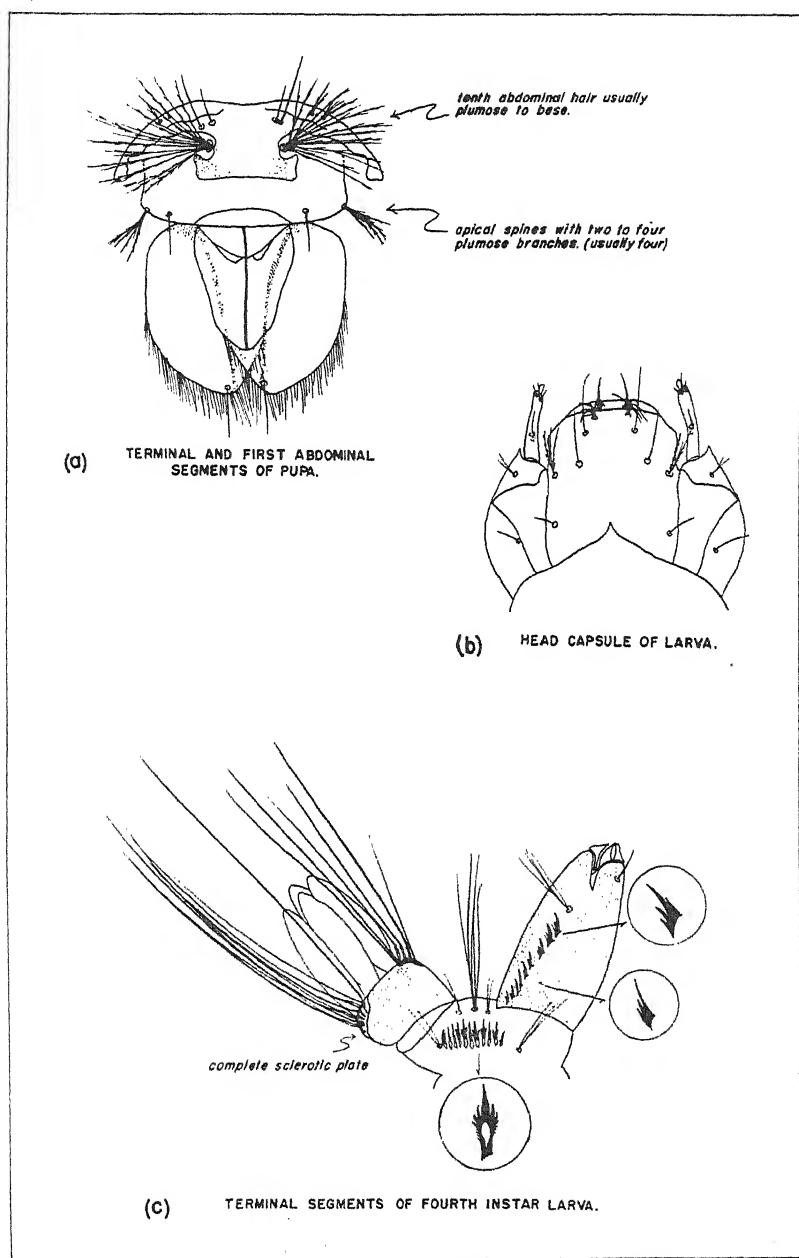
FIG. 1.   *Aedes pernotatus* Farner and Bohart. Morphology of aquatic stages.

typical "jungle" habitats, the native populace in forested areas as cacao and coconut groves are not infrequently plagued by adult mosquitoes.

Examination of the fourth instar larvae reveals an incomplete but rather smoothly marginated sclerotic plate which was modified in structure and form in the progeny produced in crossbreeding *hebrideus* females with *pernotatus* males. Attention was drawn to this variation in form before the beginning of the present study. The impression of the investigator at that time was that a hybrid was present in nature or a distinct species remained to be described from this area. Because of the scarcity of specimens and the high mortality rates in these observed larvae, no adults were reared for comparison with those obtained as progeny of *hebrideus* females crossed with *pernotatus* adults.

TABLE I

BIOLOGICAL DATA ON AEDES HEBRIDEUS

SPECIMEN NUMBER	SOURCE	NO. EGGS DEPOSITED	DAYS REQUIRED FOR HATCHING	LENGTH LARVAL STAGE	LENGTH PUPAL STAGE
H₁	FIELD (TIN CAN)	56	2 DAYS	6 DAYS	I DAYS
H₂	FIELD (TREE HOLE)	35	2 DAYS	8 DAYS	2 DAYS
H₃	FIELD (CHICKEN PEN)	60	NON-FERTILE	———	———
H₄	FROM H COLONY	29	5 DAYS	4 DAYS	2 DAYS
H₅	FROM H COLONY	105	4 DAYS	4 DAYS	2 DAYS
H₆	FIELD (TREE TRUNK)	59	3 DAYS	4 DAYS	2 DAYS
H₇	FROM H COLONY	33	3 DAYS	4 DAYS	2 DAYS
H₈	FIELD (BITING MAN)	20	3 DAYS	5 DAYS	2 DAYS
AVERAGE		48.3	3	5	1.8

The markings on the abdominal tergites are illustrated in figure 4. In a long series examined by the author, the segments were banded somewhat medially with white scales. The bands extended from segments II to VII although there was a faint interruption of scaling on II and III. Except for some variation in the ratio of the width of the bands on the hind tarsi, the markings were nearly similar to those of *pernotatus*. On the fore- and mid-tarsi only basal patches of white scales are present on segments I and II.

AEDES (STEGOMYIA) PERNOTATUS FARNER AND BOHART (FIGS 1 AND 3)

Although only a small number of adult females are indistinguishable morphologically from *Aedes pseudoscutellaris*, *pernotatus* was erroneously reported from Espiritu Santo as *pseudoscutellaris* by workers at an earlier date.

Medically, this differentiation was of military importance in view of the reports of Byrd and St. Amant from Samoa (1945) that *pseudoscutellaris* collected in nature exhibited a 9.9 percent infectivity rate. Eighty percent of experimentally infected mosquitoes showed larvae of *W. bancrofti* in developing stages 14 days following infective blood meals. Of those collected in nature many carried dual or triple infec-
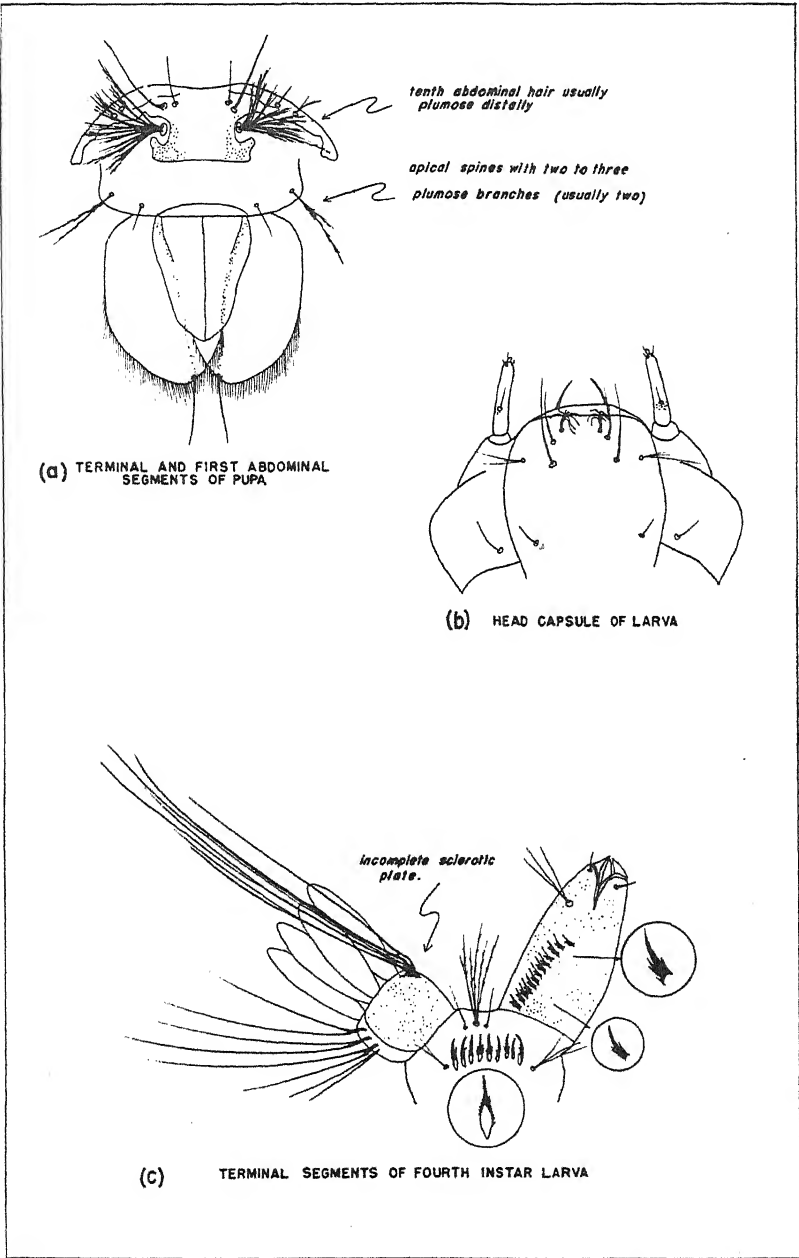
FIG. 2. *Aedes hebrideus* Edwards. Morphology of aquatic stages.

tions, and more than 15 percent of those infected were found to harbor the infective stage larvae when dissected.

A. pseudoscutellaris is also a known vector of dengue in many of the endemic areas in the South Pacific.   In a personal communication with Lever, it was reported to be an important agent in the transmission of this virus in the Fiji Islands.

The dissimilar anatomical features of *pseudoscutellaris* as reported from the New Hebrides was emphasized by Perry in early 1944 at which time a large number of specimens were examined in preparing keys to the mosquitoes of the New Hebrides.   Farner and Bohart (1944), working with comparative material in the U. S. National Museum,

TABLE II

BIOLOGICAL DATA ON AEDES PERNOTATUS

SPECIMEN NUMBER	SOURCE	NO. EGGS DEPOSITED	DAYS REQUIRED FOR HATCHING	LENGTH LARVAL STAGE	LENGTH PUPAL STAGE
P_1	FIELD (TREE HOLE)	5	NON-FERTILE		
P_2	FIELD (TREE HOLE)	105	8 DAYS	5 DAYS	2 DAYS
P_3	FROM P CAGE	42	3 DAYS	5 DAYS	3 DAYS
P_4	FROM P CAGE	10	3 DAYS	4 DAYS	2 DAYS
P_5	FIELD	71	NON-FERTILE		
P_6	FROM P CAGE	48	5 DAYS	6 DAYS	2 DAYS
P_7	FIELD	9	4 DAYS	7 DAYS	2 DAYS
P_8	FROM P CAGE	21	8 DAYS	5 DAYS	2 DAYS
AVERAGE		35.1	5.3	5.3	2.1

subsequently completed descriptions of this species for incorporation in their synopsis of the known Australasian species of the *scutellaris* group.   These authors list the *Aedes scutellaris* var. *pseudoscutellaris* (Theobald) of Daggy in their synonymy, and it was redescribed as a new species, *Aedes pernotatus*.

The important feature relative to the biting habits of the females not available at that time, was their reluctance to feed on man.   Adults have never been collected biting in nature, and they were induced with difficulty to take blood meals from human subjects in the laboratory. This biological character partially explains the species' inability to transmit filariasis and dengue and our failure to maintain experimental colonies for long periods of time.

The life cycle of *Aedes pernotatus* differs insignificantly from that of *A. hebrideus*.   In examining large number of larvae, those of *pernotatus* appeared somewhat smaller and darker in color than those of *hebrideus*. When isolated along the margins of containers, the larvae are less active and move about in a sluggish crawl in contrast to the wiggling, forceful movements of *hebrideus*.   Larvae collected in nature are usually taken in pure culture, and their preference for artificial containers is not unlike that of *hebrideus*.

As in *hebrideus*, blood meals are necessary for the production of
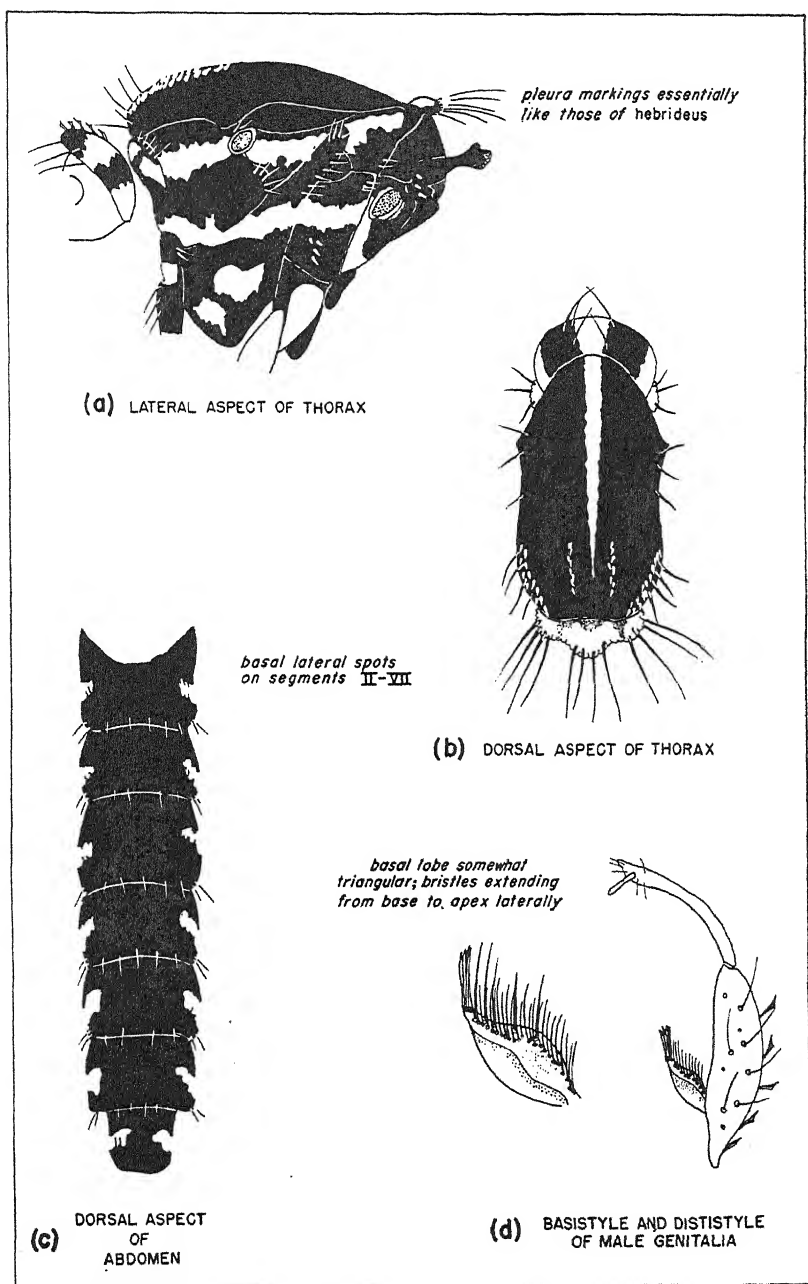
FIG. 3.   *Aedes pernotatus* Farner and Bohart.   Morphology of adult.

viable eggs. It has been noted that as many as three separate batches of eggs were deposited by females during a two-day period after one attempt in copulation.

The abdominal markings of the adults are conspicuously reduced, existing merely as basal lateral spots on segments II to VII. The fore and hind tarsi exhibit patches of white scales on segments I, II, III, and frequently on IV and V.

TABLE III

SPECIMEN NUMBER	SOURCE	NO. EGGS DEPOSITED	DAYS REQUIRED FOR HATCHING	LENGTH LARVAL STAGE	LENGTH PUPAL STAGE
PH1	CAGE BRED	70	NON-FERTILE	———	———
PH2	CAGE BRED	4	NON-FERTILE	———	———
PH3	CAGE BRED	20	NON-FERTILE	———	———
PH4	CAGE BRED	11	NON-FERTILE	———	———
PH5	CAGE BRED	40	NON-FERTILE	———	———
PH6	CAGE BRED	35	NON-FERTILE	———	———
AVERAGE		30	———	———	———

AEDES PERNOTATUS FEMALES CROSSED WITH AEDES HEBRIDEUS MALES

The difficulty encountered in inducing adult females to feed on human or animal subjects has been referred to earlier. Laboratory colonies could not be maintained, and it became necessary to collect resting female adults in nature and return them for biological studies under insectary conditions. In four collections made at separate areas on Espiritu Santo, blooded females were captured in natural environments and returned for study. Of these four, the ova produced by two were infertile. The remaining two produced typical larvae of *pernotatus*. These are illustrated in fig. 1.

Laboratory colonies of *pernotatus* females were then established from individually reared larvae. Selected female adults, after taking a blood meal, were placed in cages with male *hebrideus*. Copulation was observed in all instances. There was no undue delay in the production of ova, although the average number deposited was less than that which the female of either species produced individually. No larvae emerged from any individual sample in spite of attempts to incubate them in naturally occurring waters, distilled or especially prepared infusion mixtures.

AEDES HEBRIDEUS FEMALES CROSSED WITH AEDES PERNOTATUS
MALES (FIG. 5)

The ease with which *hebrideus* females became established in the laboratory permitted study of a longer series of adults for statistical evaluation than was possible with *pernotatus*.

In a series of 37 individually reared females subsequently crossed with adult males of *pernotatus*, 34 produced ova that were infertile.

pleura with conspicuous white
scales arranged in two parallel
longitudinal stripes and several
scattered spots

(distinguishing feature of the
"scutellaris" group)

(a) LATERAL ASPECT OF THORAX

complete abdominal bands
usually on III-VI

(b) DORSAL ASPECT OF THORAX

basal lobe somewhat narrow
but expanded laterally.
4 large setae located
apically on tubercles

(c) DORSAL ASPECT
OF
ABDOMEN

(d) BASISTYLE AND DISTISTYLE
OF MALE GENITALIA

FIG. 4.   *Aedes hebrideus* Edwards.   Morphology of adult.

The egg production, however, was somewhat increased. An average of 65 eggs was produced from these 37 specimens. The life cycle, with particular reference to the aquatic stages, remained essentially similar to that of the *hebrideus* observed in nature.

Larvae produced from fertile eggs of three specimens resembled those of *hebrideus* in motility and color. Morphologically the greatest variation was observed in the structure and architecture of the sclerotic plate of fourth instar larvae.

The sclerotic plate varied from a nearly fused but rather irregular plate to one fused but deeply indented ventrally between the proximal and distal portions of the segment. The pecten teeth and comb scales of the first generation had characteristics of the maternal *A. hebrideus*. This tendency for the first generation progeny to resemble the parent

TABLE IV

BIOLOGICAL DATA ON AEDES HEBRIDEUS FEMALES CROSSED WITH
AEDES PERNOTATUS MALES

SPECIMEN NUMBER	SOURCE	NO. EGGS DEPOSITED (avg.)	DAYS REQUIRED FOR HATCHING. (avg.)	LENGTH LARVAL STAGE. (avg.)	LENGTH PUPAL STAGE. (avg.)
HP I TO HP 16 (INCL.)	REARING CAGE	40	NON-FERTILE	———	———
HP 17	REARING CAGE	?	Larvae with irregular plates, incomplete with rough opposing edges.		
HP 18 TO HP 26 (INCL.)	REARING CAGE	73	NON-FERTILE	———	———
HP 27	REARING CAGE	74	3 DAYS	5 DAYS	2 DAYS
HP 28 TO HP 32 (INCL.)	REARING CAGE	60	NON-FERTILE	———	———
HP 33	REARING CAGE	83	6 DAYS	4 DAYS	2 DAYS
HP 34 TO HP 37 (INCL.)	REARING CAGE	63	NON-FERTILE	———	———
AVERAGE		65.5	5.1	4	2

female was noted in the many studies conducted by Toumanoff (1939) with *A. aegypti* and *A. albopictus*. A few minor differences were noted in the chaetotaxy of the immature forms.

The adults closely resembled *hebrideus* in markings on the abdominal tergites, these being complete on at least one or two segments with interrupted and spottily appearing scales on others. The tarsal markings resembled those of *hebrideus*. Of the 18 adults obtained from larvae of the first generation, all were females, and no males were obtained for terminalia studies.

The females do not feed as avidly as *hebrideus*, but they have been induced to take blood meals from human subjects.

SECOND GENERATION PROGENY FROM HEBRIDEUS FEMALES CROSSED
WITH PERNOTATUS MALES (FIG. 6)

Eighteen adult females of the first generation were successfully reared and separated. Individually reared *pernotatus* males were again introduced into separate cages with the *hebrideus* females. Fifteen of the total 18 produced an average of 31 non-fertile ova per female. The remaining three produced an average of 32 fertile ova.

The length of the aquatic stage lasted about seven days with three days required for emergence of larvae.

The characteristic feature again was in the fourth instar larvae. There was marked gradation in degree of affinity of the sclerotic plate. The larvae exhibited plates varying from a fused and slightly indented

(a) SCLEROTIC PLATES AND PECTEN TEETH OF 4TH INSTAR LARVAE

(b) DORSAL ABDOMINAL MARKINGS OF ADULT FEMALES

FIG. 5.   *Aedes hebrideus* females crossed with *Aedes pernotatus* males.   Selected variations in larvae and adults of first generation progeny.

one with irregular margins to one with a wide "bridge" fusion, irregularly bordered.   There was a remarkable alteration in structure of the pecten teeth and comb scales in some, being poorly formed, reduced in number, and not representative of either species.

All but five of the larvae died before reaching the pupal stage. These pupated after a delay of five days. The female was not well formed and died immediately upon emergence. Four males were obtained, and the terminalia pattern of these hybrid progeny are reproduced in figure 6. Grossly, the abdominal markings were intermediate between those of *hebrideus* and *pernotatus*. The pale scales were rather unevenly distributed with nearly complete banding on the fourth and seventh tergite of two specimens.

Of the available skins for study, the pupal characteristics of first and second generation progeny were not remarkable. It was not possible to separate these forms from the prepared skins of *A. hebrideus*.

TABLE V

BIOLOGICAL DATA ON SECOND GENERATION PROGENY IN CROSSING AEDES HEBRIDEUS FEMALES WITH AEDES PERNOTATUS MALES

SPECIMEN NUMBER	SOURCE	NO. EGGS DEPOSITED (avg.)	DAYS REQUIRED FOR HATCHING (avg.)	LENGTH LARVAL STAGE (avg.)	LENGTH PUPAL STAGE (avg.)
HP 17-1 TO HP 17-7 incl.	ADULTS FROM PROGENY HP17	43	NON-FERTILE	————	————
HP 17-8	ADULTS FROM PROGENY HP17	29	5. Only one larva emerged.	4 DAYS	3 DAYS
HP 17-9 TO HP 17-12 incl.	ADULTS FROM PROGENY HP17	37	NON-FERTILE	————	————
HP 17-13	ADULTS FROM PROGENY HP17	41	6 DAYS	4 DAYS	2 DAYS
HP17-14 TO HP17-16 incl.	ADULTS FROM PROGENY HP17	32	NON-FERTILE	————	————
HP 17-17	ADULTS FROM PROGENY HP17	28	4 DAYS	4 DAYS	2 DAYS
HP 17-18	ADULTS FROM PROGENY HP 17	13	NON-FERTILE	————	————
AVERAGE		31.8	3	4	2.3

SUMMARY AND CONCLUSIONS

1. Biological and crossbreeding studies were made on two closely related forms of the "*scutellaris*" group of mosquitoes from the New Hebrides islands.

2. Two morphological species, *Aedes hebrideus* and *Aedes pernotatus*, with no apparent intergrades found in nature have been shown to hybridize in the laboratory with great difficulty.

3. No fertile ova were produced in crossbreeding studies between female *Aedes pernotatus* and male *Aedes hebrideus*.

4. Fertile ova were produced in crossbreeding studies between female *Aedes hebrideus* and male *Aedes pernotatus*.

5. Intergrading characters are produced in larvae and in adults of the first generation with the progeny exhibiting characters of the maternal type *Aedes hebrideus*. The larvae showed greatest variation in the sclerotic plate which varied from an incomplete structure with rough opposing ends to a fused but deeply indented pattern ventrally.

6. Second generation progeny exhibited even greater alteration in structure of the sclerotic plate. This varied from a fused, irregularly emarginated saddle to a wide "bridge" fusion. The pecten teeth and comb scales of some were poorly developed. Four males were obtained,

comb scales
poorly developed

pecten teeth
poorly developed

(a) SCLEROTIC PLATES AND PECTEN TEETH OF 4TH INSTAR LARVAE

(b) DORSAL ABDOMINAL MARKINGS OF ADULT FEMALES

basistyle and dististyle
resemble that of pernotatus
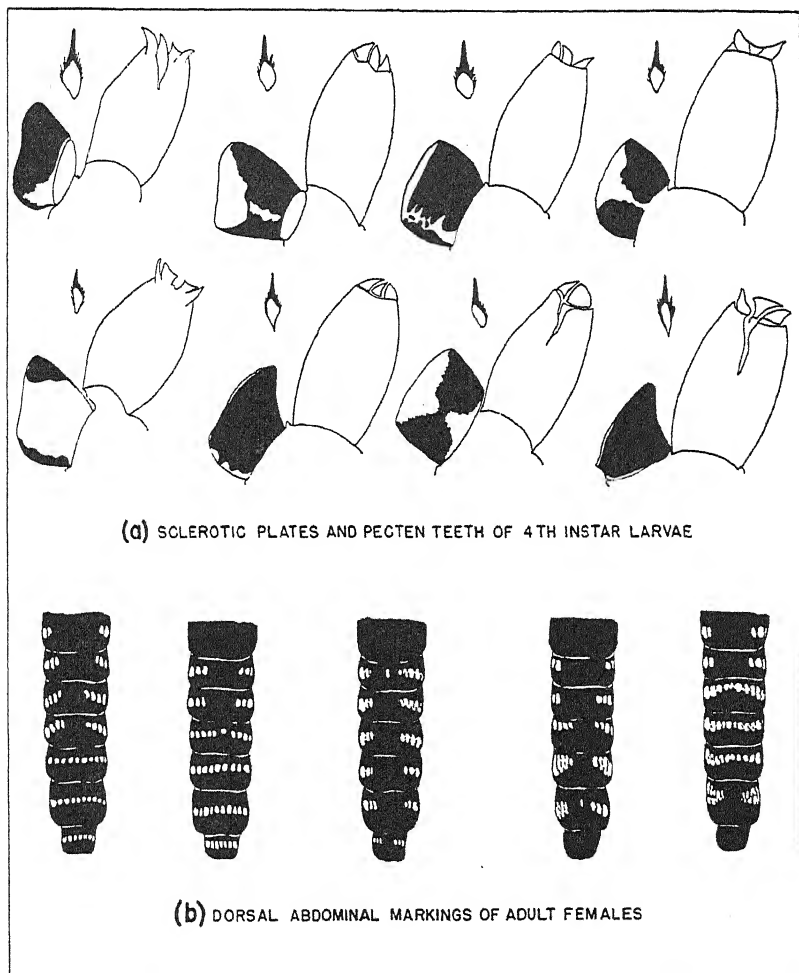
(c) TERMINALIA CHARACTERISTIC OF ADULT MALES
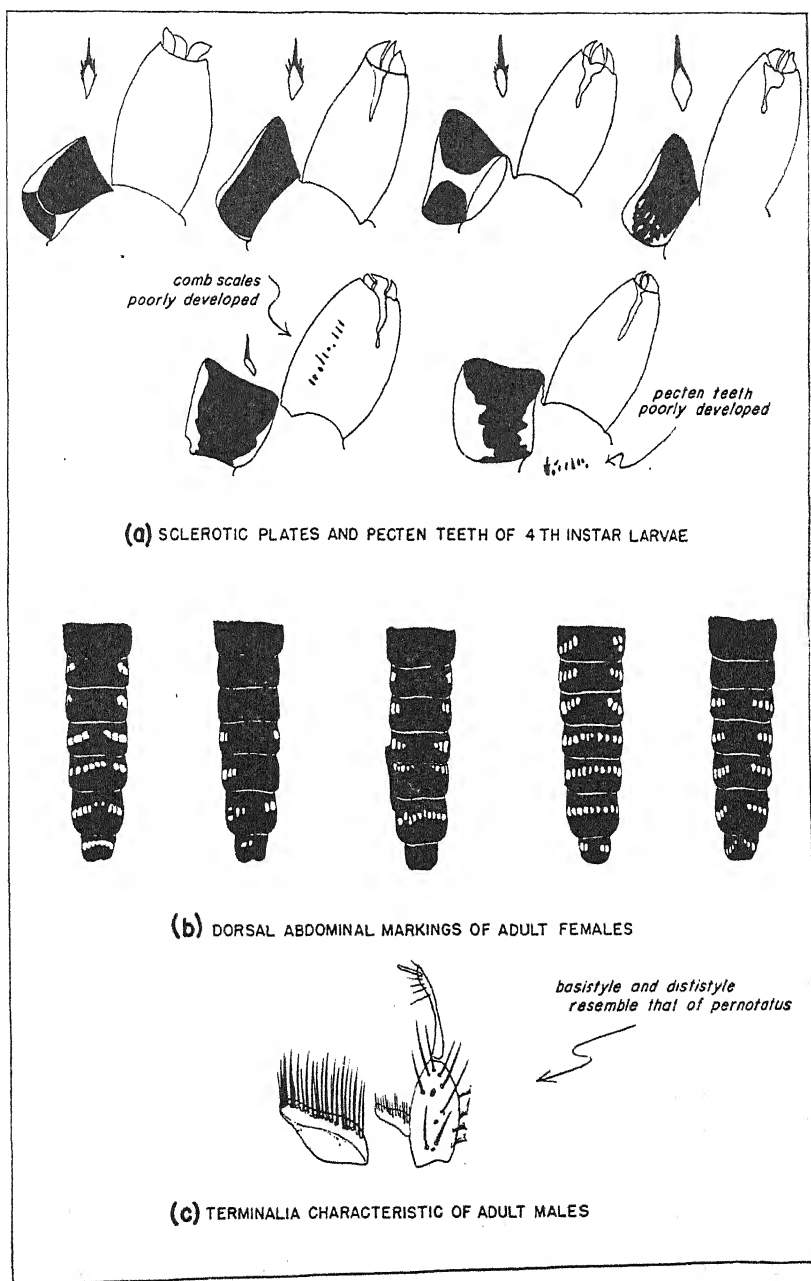
FIG. 6.   *Aedes hebrideus* females crossed with *Aedes pernotatus* males.   Selected variations in larvae and adults of second generation progeny.

with a terminalia pattern similar to *pernotatus*. Only one imperfectly developed female adult was obtained.

7. *Aedes hebrideus* and *Aedes pernotatus* are true morphological species as indicated by their morphological differences and their ability to hybridize only with extreme difficulty under laboratory conditions.

8. Hybridization in nature between these two closely related species (taxonomically and geographically) is rare and is not an important factor in the present evolution of the group.

9. The medical importance of *Aedes hebrideus* and *Aedes pernotatus* on these islands is not significant. *Aedes pernotatus* does not feed readily on man, and *Aedes hebrideus* epidemiologically is not responsible for the transmission of dengue or filariasis.

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   This catalogue is based on records in the literature and on the insects present in the collections of the Department of Entomology of the National Museum of Natural History, Paris. Species are listed in taxonomic order, with the known distribution given for the territory covered and with bibliographical references.

—M. T. J.

NEW SPECIES OF SIMULIIDAE (DIPTERA) FROM GUATEMALA II[1]

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In a paper now in press (1) the author described three new species of simuliids from Guatemala and gave notes on their ecology and distribution. The present work is a continuation in which three additional species are described.

Simulium (Dyarella) delatorrei, new species

Female.—3.1 mm. long.

Head: Dichoptic. Antennae 11-segmented, very deeply inserted, first segment small, third segment only slightly longer than second; first two segments yellow, the others dark brown. Frons, clypeus, and occipital region black, completely covered by greyish-white pruinosity; occipital, frontal, and clypeal hairs black. Fronto-ocular triangle 44 μ in height, the base 72 μ. Bucco-pharyngeal apparatus not heavily sclerotized, the lateral processes hardly more expanded or thickened than the border of the median space; without teeth.

Thorax: Mesonotum black, the anterior three-fourths grey pruinose except for two narrow bands of the ground color which extend longitudinally, one on each side of the midline; each band is contiguous, at its anterior end, with a grey, pruinose, wedge-shaped patch which extends from the anterior margin of the mesonotum; lateral margins of mesonotum black; black pilosity sparsely distributed over entire surface, the hairs being longer and more numerous on the posterior median area; narrow, appressed, golden scales also adorn the mesonotum, these being more numerous along the periphery. Scutellum reddish-brown with black pilosity. Postnotum reddish-brown with two symmetrical triangular patches of greyish-white pruinosity on anterior margin, one on each side of the midline; without pilosity. Stem of halter brown, knob yellowish-white. Wings, 3.3 mm. long; Sc pilose except near its distal end; R_1 pilose only along the distal two-thirds; R_{2+3} simple, pilose except along a very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 3.0 mm.; coxa and trochanter yellow; femur and tibiae yellow except for a small apical dark brown band on the

latter; tarsus completely black.   Leg 2—Length, 2.7 mm.; coxa dark brown, trochanter yellow; femur yellow with minute apical dark patch on dorsal face; tibia yellow with dark brown apical band; basitarsus yellow along basal half, the distal half and remaining tarsal segments black.   Leg 3—Length, 3.4 mm.; same color patterns as on leg 2 with the exception of the basitarsus which is yellow along the basal two-thirds; spines on outer ventral margin of basitarsus numerous, strongly pointed, and comparatively long (50 μ); calcipala distinct but narrow and rather short; pedisulcus indicated but not deeply incised, rather distant from calcipala; claw with basal heel somewhat spine-like and with submedian tooth.

Abdomen: First two segments dark brown with grey pruinosity; third, fourth, fifth, and eighth segments dark brown, dull; sixth and seventh segments shiny yellow; ninth tergite and the genitalia yellow. Entire dorsal surface of abdomen clothed with short black hairs. Sternites grey pruinose.

Genitalia: Anal lobe broadly truncate, with narrow antero-dorsal projection; antero-ventral angle heavily clothed with hairs; ventral border hardly extending beyond the ventral limit of cercus.   Cercus rounded, longer than high (fig. 1).   Genital rod (fig. 2) narrow with extensive, broad, basal dilatation; arms with somewhat quadrangular expansions.   Ovipositor intimately associated with the anal lobe, so much so, that in profile the ovipositor almost completely masks it; ovipositor with bulbous basal section and with elongated, conical, very sharply pointed distal section; extends ventrally.

Male.—2.6 mm. long.

Head: Holoptic.   Eyes black.   Antennae 11-segmented, the first two segments dark yellow, the others black.   Palpi black.   Clypeus silvery pruinose with black pilosity.

Thorax: Mesonotum velvety-black, the anterior three-fourths clothed with silvery-grey pruinosity except for a median triangular patch which is contiguous with the anterior margin and extends one-fourth the way back, and two longitudinal stripes which extend along the middle half of the notum, one on either side of the mid-line; the stripes broaden posteriorly; the appearance of the black basic color in the areas mentioned divide the pruinose zone into three distinct patches. Narrow, appressed, pale yellow scales investing entire notum, more abundant on anterior half and along lateral margins.   Posterior medial area grey-pruinose, with some yellow scales and with numerous black hairs.   Scutellum velvety-black with black pilosity.   Postnotum same color as scutellum but with two triangular tan pruinose patches, one on either side of the midline, contiguous with the anterior margin. Halteres with brown stem and yellowish knob.   Wings, 2.9 mm. long. Sc bare except for a very few hairs along short section at its base, R_1 bare only along basal third; R_{2+3} simple, pilose except along its basal third; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 2.9 mm.; coxa black, trochanter yellow with fringe of black hairs; femur with yellow ventral edge and black dorsal edge; yellow on inner aspect with a wide, median, longitudinal band of stiff black hairs which give that face of the femur a striped appearance; ventral margin of outer aspect yellow, the rest black; tibia with apical
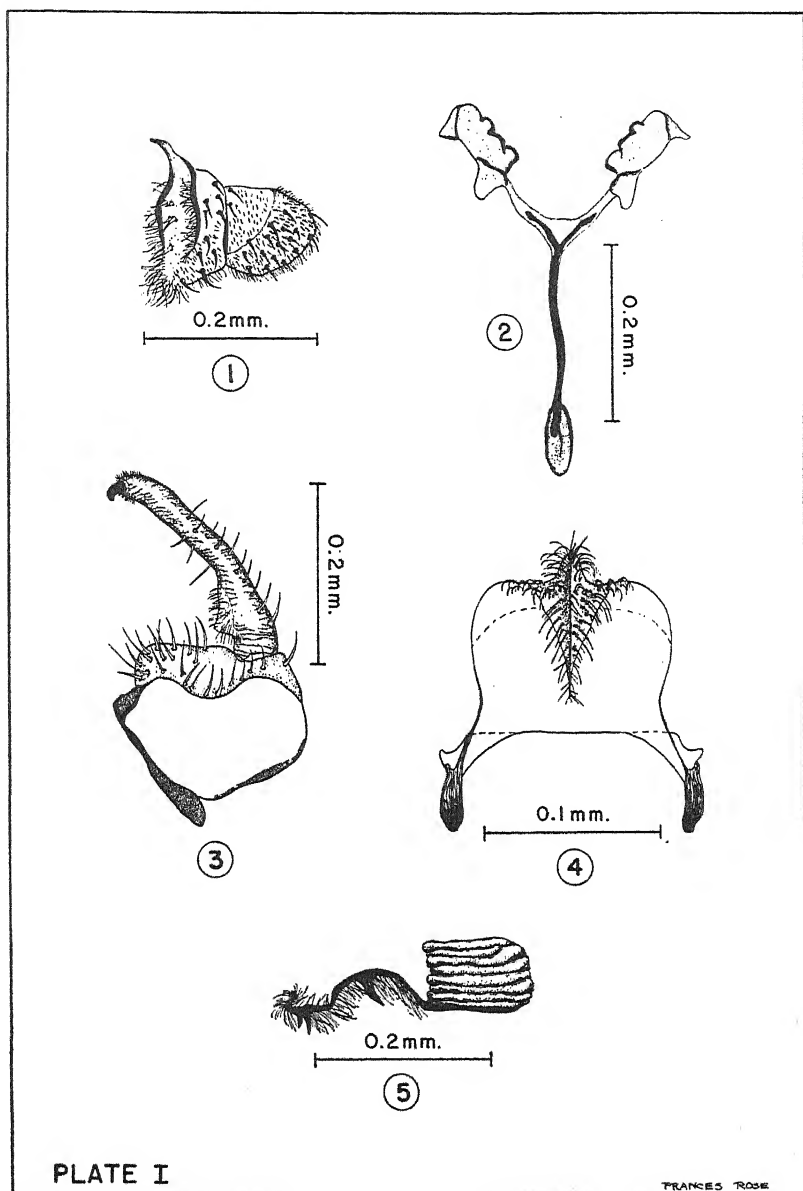
Simulium (*Dyarella*) *delatorrei*, n. sp. Fig. 1. Cercus and anal lobe of female.
Fig. 2. Genital fork of female. Fig. 3. Sidepiece and clasper of male (dorsal
view). Fig. 4. Adminiculum of male (ventral view). Fig. 5. Adminicular arm
and lateral plate.

and distal black rings, and central white area on its outer aspect; inner aspect all white; all white areas clothed with white hairs; tarsus completely black.   Leg 2—Length, 2.7 mm.; coxa black, trochanter dark yellow with fringe of black hairs; femur deep yellow except for small apical dark brown ring; tibia yellow along basal three-fourths, black on distal fourth; basal third of basitarsus dark yellow, the remainder, as well as all other tarsal segments, black.   Leg 3—Length, 3.3 mm.; coxa black, trochanter dark brown; femur black except for small basal yellow ring; tibia yellow on basal two-fifths, the remainder black; basal half of basitarsus yellow, the distal half, and all other tarsal segments black; basitarsus broadly expanded; calcipala and pedisulcus well developed.

Abdomen: Velvety-black.   Tergite and pleurites of second segment silvery pruinose; pleurites and lateral margins of tergites of sixth and seventh segments similarly pruinose; eighth tergite grey-pruinose. Posterior margin of second segment, especially on the pleurites, with band of dense, black hairs, so long that they reach at least to the posterior margin of the fourth segment.   Sternites dull-grey pruinose.

Genitalia: Sidepiece wider than long.   Clasper longer than wide, 1.8 times as long as sidepiece; very narrow, wide inwardly projecting basal process which is clothed with short hairs; apex with crown of minute, heavily sclerotized, spine-like processes and with a single, stout, blunt, apical spine.   All hairs of sidepiece and clasper comparatively short and weak (fig. 3).   Adminiculum longer than wide with large, strongly sclerotized basal processes; body of adminiculum with apical prolongation and with ventral keel, both of which are well haired; small, lateral, hyaline, wing-like structures extending from body of adminiculum near basal processes (fig. 4).   Adminicular arms heavily haired, with two apical teeth and another similar tooth about halfway along its length; lateral plate quadrangular (fig. 5).

Pupa.—Cocoon: Greatest length, 3.5 mm.; with simple, parchment-like texture, with slight collar, and with no thickening of the rim around anterior aperture; ventral surface woven along posterior half only (fig. 6).

Filaments: Respiratory apparatus of each side composed of a very massive, horn-like dorsal element, a smaller ventral element, and a short, tail-like extension of the dorsal element which is directed mesad (figs. 6 and 7).   Filaments with pseudo-articulations and with rather regularly arranged striations perpendicular to the transverse annulations.   Length of dorsal element of respiratory apparatus as measured from above, 1.8 mm.

The pupa of *estevezi* Vargas (4) appears similar to that of *delatorrei* but it differs in the following characters: *Simulium (Hearlea) estevezi* does not show distinct striations perpendicular to the primary pseudo-articulations of the dorsal element of the respiratory apparatus.   In *estevezi* this same element is longer and narrower, tapering more to a point; after projecting anteriorly a short distance, it curves acutely downward so that it is practically parallel to the ventral element, and then it recurves, continuing anteriorly, being almost contiguous with the substratum; this horizontal, apical section is very spatulate.   The pupal filaments of *delatorrei* are also somewhat similar to those of
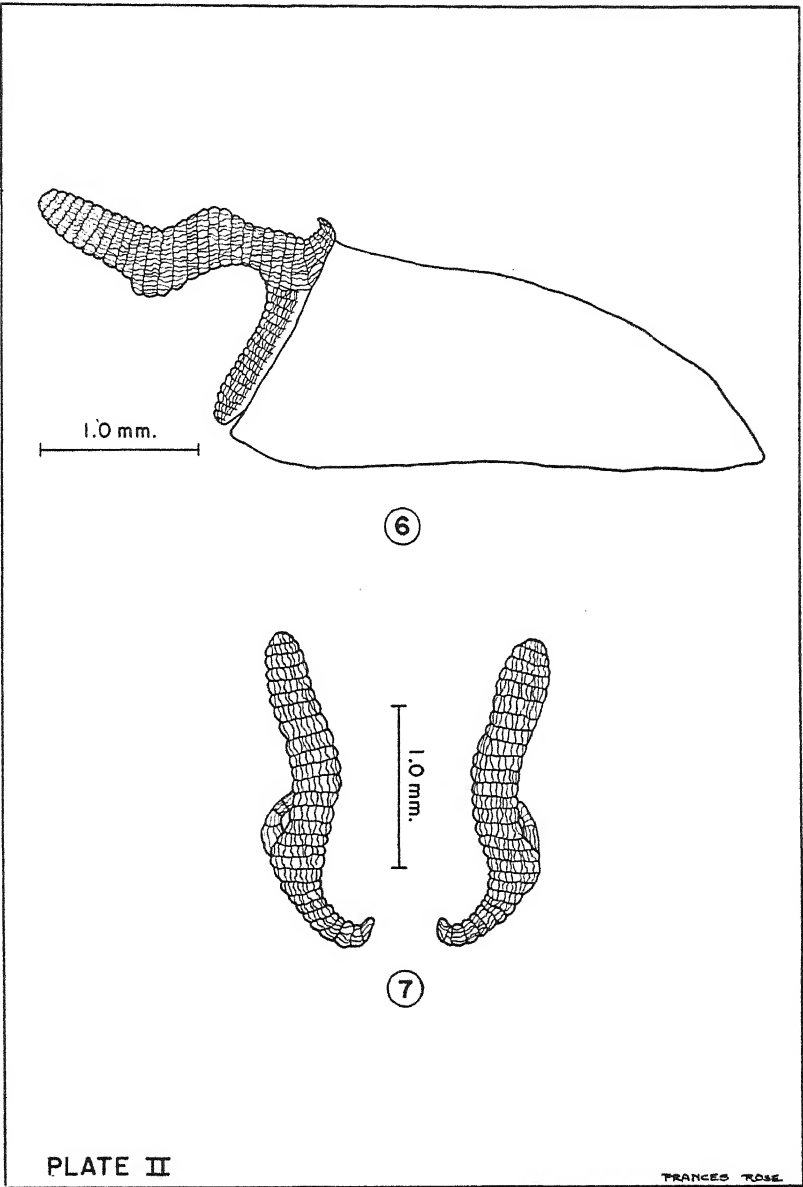
Simulium (Dyarella) delatorrei, n. sp.   Fig. 6. Cocoon (in profile).   Fig. 7. Pupal respiratory filaments.

canadense Hearle (2), but in the latter species the dorsal element is more bulbous, with tubercle-like expansions near the distal end, and it does not curve ventrad.

Ecological Notes.—*Simulium* (*Dyarella*) *delatorrei* has been found in the highlands of Guatemala in the Departments of Sololá, Totonicapán, and San Marcos at altitudes ranging from 5250 feet to 9470 feet, and in the Department of Chimaltenango at an altitude of 6272 feet. The streams ranged from narrow run-off ditches to ones almost ten feet wide, the majority being of the wider type. The depths varied from 4 inches to one foot. The pH, from 6.4 to 7.4. Temperature, from 8° C. to 19° C. Current speed, from 8 inches per second to that of a waterfall, with the majority having a speed of about 24 inches per second. In almost all cases the collecting spots were exposed to the sun; the river beds were always composed of sand, with small and large stones, and at times, with small quantities of mud. The pupae were found attached to leaves of emergent vegetation, to stones, twigs, and to pine needles that had fallen onto the surface of the water. All collections were made during the months from October to April. Other species found breeding in the same streams were: *S. veracruzanum* Vargas, *smarti* Vargas, *metallicum* Bellardi, *capricornis* de León, *callidum* Dyar & Shannon, *rubicundulum* Knab, *aureum* (Fries), *tricornis* de León, *wrighti* Vargas, and *microbranchium* Dalmat.

Types.—*Holotype:* Female (Accession 6P-8); reared from pupa collected in the Río Samalá, Totonicapán, Guatemala, on February 24, 1949, by Jaime Rosales G. and Herbert T. Dalmat; prepared on five slides consisting of the head, bucco-pharyngeal apparatus, wings, legs, and genitalia; pupal skin and cocoon in alcohol. *Allotype:* Male (Accession 6T-2); reared from pupa collected in same river as holotype on March 5, 1949, by Jaime Rosales G. and Adán Flores; specimen on minute nadel, with one wing mounted on slide; pupal case and cocoon in alcohol. *Paratypes:* One female (6T-11) reared from pupa collected with allotype; adult pinned and pupal skin and cocoon in alcohol. One male (6T-19) from same collection; legs, wings, and genitalia mounted on slides, the rest discarded because of poor condition; pupal skin and cocoon in alcohol. One female (I-18) reared from pupa collected at type locality on December 11, 1947, by J. Onofre Ochoa A. and Herbert T. Dalmat; adult pinned, pupal skin and cocoon in alcohol. One female (5W-3) reared from pupa collected at Río El Molino, Finca El Tesoro, Chichicastenango, Quiché, on December 13, 1948, by J. Onofre Ochoa A., Vicente Castellanos, and Adalberto Girón; adult pinned, genitalia mounted on slide, pupal skin and cocoon in alcohol. One male (F-10) reared from pupa collected at the sides of the smaller waterfall just beyond Panajachel, Sololá, on December 9, 1947, by J. Onofre Ochoa A. and Herbert T. Dalmat; adult pinned, pupal skin and cocoon in alcohol. One female (FF-2) reared from pupa collected at type locality on April 6, 1948, by Helvidio Ochoa and Herbert T. Dalmat; adult pinned, pupal skin and cocoon in alcohol. Two females and one male (Acat. 652-3, 5, 4) reared from pupae collected in the Río Ciprés, Aldea los Pajales (Acatenango, Chimaltenango) on April 13, 1949, by Carlos R. Santizo P. and Juan Marroquín G.; adults pinned on minuten nadeln, pupal cases and cocoons in alcohol. One female

(I-21A) dissected from pupa collected with female I-18; slide prepared
of head, bucco-pharyngeal apparatus, wings, legs, and genitalia. One
male (I-21B) dissected from pupa collected with female I-18; slides
prepared of legs and genitalia. Pupal skins and cocoons of last men-
tioned female and male preserved in alcohol. Six pupae (6W-6) collected
in the Río Patanatic #3, Panajachel, Sololá on March 16, 1949, by
J. Onofre Ochoa A., Vicente Castellanos, and Adalberto Girón. One
pupa (J-11) collected at the Río Guatayil, Aldea Chamaco, San Marcos,
on December 14, 1947, by J. Onofre Ochoa A. and Herbert T. Dalmat;
genitalia mounted on slide of adult female dissected from pupa. One
female (4X-23) and one pupa (4X-27) collected at type locality on
October 5, 1948, by J. Onofre Ochoa A., Adán Flores, and Carlos
Ochoa; adult pinned. Nine pupae (6T-20) collected with allotype.
Five pupae (I-21) collected with female I-18. One pupa (FF-17)
collected with female FF-2. One pupa (F-17) collected with male F-10.

Holotype and paratype male (F-10) deposited in the collection of
the United States National Museum; allotype and all other paratypes in
collection of the author.

This species has been named in honor of Mr. Luis de la Torre who,
during his stay in Guatemala, helped the author collect simuliids.

Simulium (Hearlea) ethelae, new species

Female.—3.0 mm. long.

Head: Dichoptic; eyes black. Fronto-ocular triangle 140 μ high
and 112 μ at base. Antennae 11-segmented, the first segment extremely
small and deeply inserted into head capsule; third segment as long as
the first two measured together; all segments subequal in width, the
antennae hardly tapering; first two segments yellowish-brown, all
others black. Palpi black. Bucco-pharyngeal apparatus simple, the
lateral processes and the margin between them well sclerotized. Frons,
clypeus, and occipital region black, completely covered by greyish-white
pruinosity; all hairs of these regions black.

Thorax: Mesonotum black; with the head of the fly oriented forward
and the light source directed from in front at a 45° angle to the dorsum,
there is seen on the mesonotum a broad, longitudinal, median, grey
pruinose band which starts about one-eighth the way back from the
anterior margin; a similar longitudinal band is present on each side of
the median one, separated from it by a narrow black stripe; that part of
the mesonotum anterior to each of the lateral longitudinal bands, and
also the lateral margins of the notum, silvery pruinose; golden-yellow,
scale-like hairs and short black hairs distributed over notum, the former
being more numerous on the anterior half: several long black hairs on
posterior median region. Pleura evenly grey-pruinose. Scutellum
black with numerous golden-yellow appressed hairs and long fine black
ones. Postnotum black with small patch of tan pruinosity on each side
of the midline. Stem of halter dark brown, knob yellowish-white.
Wings, 3.3 mm. long; Sc pilose along entire length; R_1 pilose only on
distal half; R_{2+3} simple (R_{4+5} absent), pilose its entire length except
for very short basal section; Cu_2 arcuate; discal cell absent.

Legs: Leg 1—Length, 3.3 mm.; coxa and trochanter yellow; femur
yellow with slight darkening at distal extremity, clothed with short,

flat, yellow hairs and stouter, longer, black hairs; tibia yellow with apical dark brown ring, clothed with white pruinosity and with similar investiture of hairs to that of femur; tarsus completely black.   Leg 2—Length, 2.9 mm.; coxa black, trochanter dark brown; femur and tibia with same color patterns as on leg 1; tarsus completely black except for narrow stripe on ventral face of basitarsus which is yellow and which bears yellow hairs.   Leg 3—Length, 3.6 mm.; coxa black, trochanter dark brown; femur and tibia yellow, each with apical dark ring; basitarsus yellow on basal two-thirds, the second segment yellow on its basal half; the remainder of these segments, as well as all other tarsal segments, black; calcipala well developed, not quite reaching the area of the pedisulcus; pedisulcus hardly indicated; claw with submedian tooth.

Abdomen: Velvety-black; tergite of segment one, and tergites and pleurites of segments two and six, grey-pruinose; posterior margin of first abdominal segment with fringe of black hairs, more dense on the pleurites.   Sternites grey-pruinose.

Genitalia: Cercus quadrangular, higher than long.   Anal lobe irregularly quadrangular, with finger-like extension projecting from posterior ventral angle.   Genital rod with expanded base, the dilatation extending for more than one-third the length of the rod; expansions at end of arms triangular and simple.   Ovipositor rather blunt and short (figs. 8 and 9).

Male.—This specimen was extracted from its pupal skin after normal emergence failed.   Only the legs and genitalia are in condition suitable for description.

Legs: All coxae with apical fringe of rather long dark hairs.   Leg 1—Length, 2.8 mm.; coxa, trochanter, and femur yellow, the femur clothed with numerous rather long, dark hairs; tibia yellow except for apical black band; tarsus black.   Leg 2—Length, 2.4 mm.; coxa dark brown, trochanter yellowish-brown; femur yellow with darker apical ring; tibia yellow along its basal three-fourths, the apical fourth and the entire tarsus black.   Leg 3—Length, 3.1 mm.; coxa dark brown, trochanter yellow; femur and tibia yellow except for dark brown band across the apex of each; tarsus black except for basal third of basitarsus and basal half of second tarsal segment which are yellow.   Tibia and tarsus greatly expanded, the tibia with two hairy extensions from the apex of its dorsal face.   Calcipala well developed; pedisulcus absent.   Basal, bulb-like dilatation of second tarsal segment on its dorsal aspect.   Claw with very minute submedian tooth.

Genitalia: Sidepiece wider than long with well-developed, dome-shaped, dorsal expansion on inner side; dorsal opening broadly quadrangular.   Clasper long and narrow, with short, blunt, apical spine arising from longitudinal furrow near distal end (fig. 10).   Body of adminiculum quadrangular, broader than long, the basal processes almost equalling it in length; apical margin with median indentation; triangularly-shaped keel extends longitudinally along ventral aspect from median indentation, with which its base coincides, to the interior basal margin; base of keel, as well as apical margin of adminiculum, with long, curled hairs; row of shorter hairs on each margin of the keel; entire ventral surface of body of adminiculum clothed with minute,
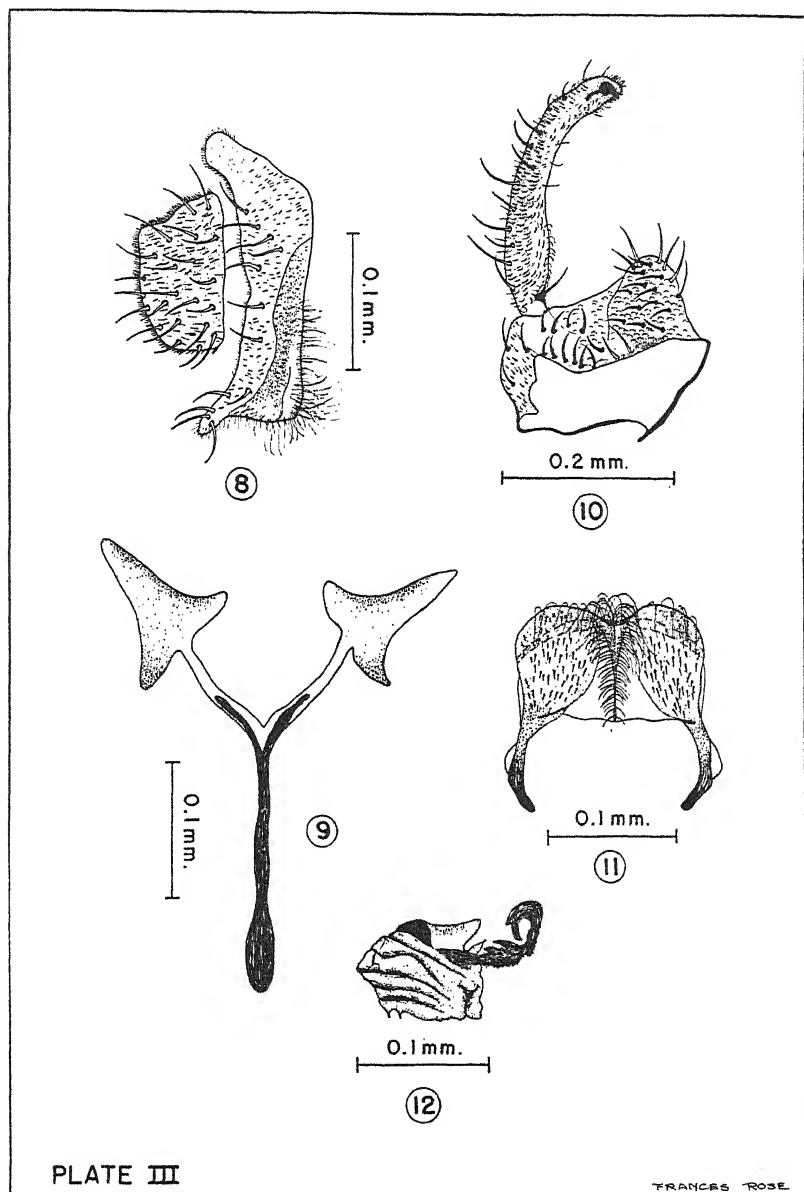
Simulium (*Hearlea*) *ethelae*, n. sp.   Fig. 8. Cercus and anal lobe of female.
Fig. 9. Genital fork of female.   Fig. 10. Sidepiece and clasper of male (dorsal
view).   Fig. 11. Adminiculum of male (ventral view).   Fig. 12. Adminicular
arm and lateral plate.

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appressed hairs; basal processes heavily sclerotized along their basal half, the outer aspect of each, in the central region, bearing a small, wing-like expansion (fig. 11). Adminicular arm heavily sclerotized, with two long teeth extending from its middle region, and with one short, blunt tooth and one longer tooth at its apex; lateral plate quadrangular and somewhat wrinkled (fig. 12).

Pupa.—Cocoon: Dorsal slope, 3.1 mm.; longest dimension, 3.8 mm.; widest dimension, 1.3 mm. Case simple, with parchment-like texture, short anterior collar, and with rim around anterior aperture of same thickness as rest of cocoon (fig. 13).

Filaments: The respiratory apparatus of each side is composed of a dorsal element and a lateroventral element, each horn-like and with pseudo-articulations. The filaments resemble those of *deleoni* Vargas (5) and *capricornis* de León (3) in general form, but they are much narrower, and the dorsal filament curves down more acutely than in these two species (figs. 13 and 14).

The shape of the claspers and adminiculum, the form of the anal lobe, and the type of pupal filaments place this species in the subgenus *Hearlea*. It can be differentiated from related members in this group as follows: From *carolinae* de León (3) by the lack of secondary branching of the pupal filaments; from *estevezi* Vargas (4) and *dalmati* Vargas (6) by the form of the adminiculum and genital rod, as well as the difference in form of the respiratory elements of the pupa; from *canadense* Hearle (2) by the lack of the small dorsal spur on the pupal filaments.

Ecological Notes.—This species has been found only in the highlands of Guatemala between 5500 and 6500 feet. It has been collected only during the dry months of November, December, and March. The width of the streams in which it has been found breeding ranges from 2.5 feet to 8 feet; the depth, from 4 to 6 inches; temperature, from 12° C. to 17° C.; the current speed, from 14 inches per second to that of a small cascade. In all cases the substratum for the pupae was either small petioles or a rock-like formation of earth. The stream beds were composed of sand, with small and large stones, and with few emergent plants. All collections were made in sections of the streams exposed to the sun. Other species found in the same streams are: *S. capricornis* de León, *rubicundulum* Knab, *carolinae* de León, *veracruzanum* Vargas, *callidum* Dyar & Shannon, *microbranchium* Dalmat, and *delatorrei* Dalmat.

Types.—*Holotype:* Female (Accession 3"0"-1), reared from pupa collected in the Río Los Arcos, near Los Encuentros, Sololá on November 4, 1948, by Luis de la Torre and Herbert T. Dalmat; adult on cork mount, pupal case and cocoon in alcohol. *Allotype:* Male (Accession 5V-7), dissected from pupal case; pupa collected at type locality on December 13, 1948, by Vicente Castellanos, Adalberto Girón, and J. Onofre Ochoa A.; genitalia, legs, and wings mounted on slides, the remainder of adult discarded due to poor condition; pupal case and cocoon in alcohol. *Paratypes:* One female (3 "0"-2), collected with holotype; adult pinned, pupal case and cocoon in alcohol. Seventeen pupae (3 "0"-6). One pupa (3 "0"-5). One pupa (3 "0"-2A). Slides prepared of head, bucco-pharyngeal apparatus, legs, genitalia, and wings of female dissected from pupa (3 "0"-6A). Slides of legs, wings,

PLATE IV

FRANCES ROSE
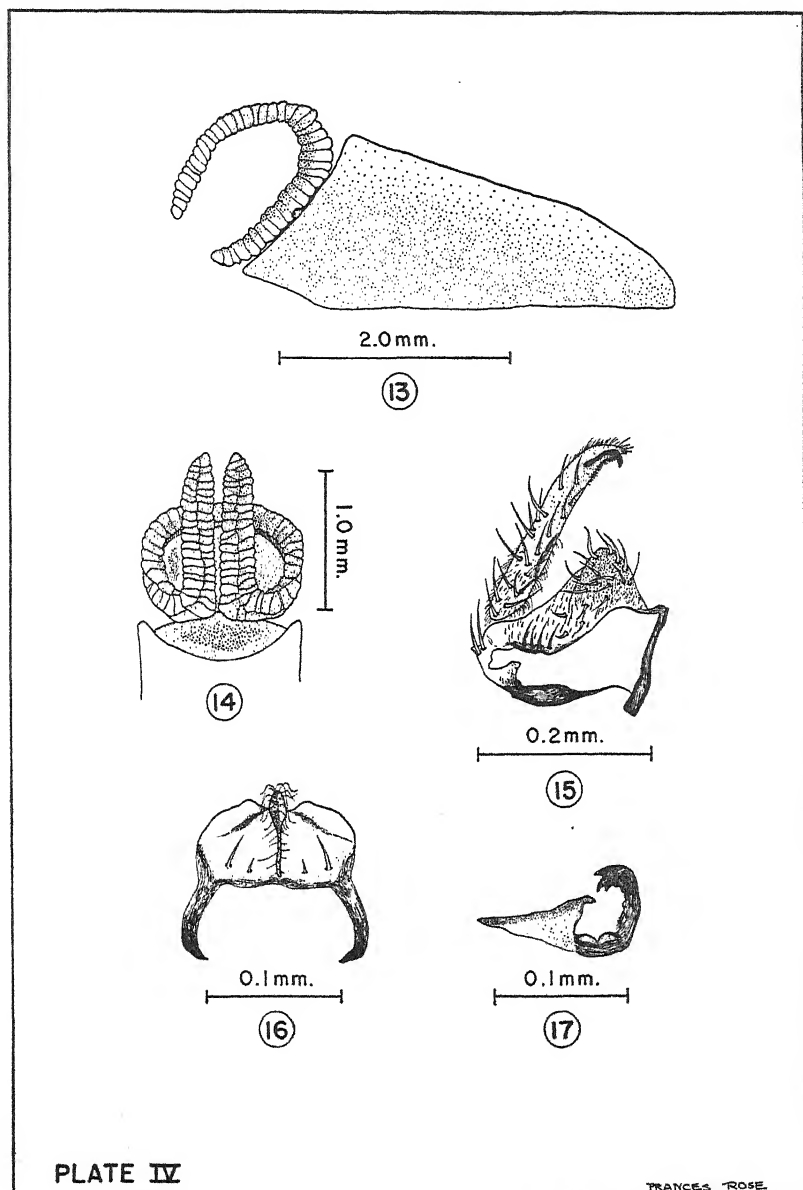
Simulium (Hearlea) ethelae, n. sp. Fig. 13. Cocoon (in profile). Fig. 14. Pupal respiratory filaments (dorsal view).
   Simulum (Hearlea) nigricornis, n. sp. Fig. 15. Sidepiece and clasper of male (dorsal view). Fig. 16. Adminiculum of male (ventral view). Fig. 17. Adminicular arm and lateral plate.

and genitalia prepared from male dissected from pupa (3 "0"-6C). Slide of genital rod prepared from female extracted from pupa (3 "0"-6B). Slides prepared of pupal filaments and genitalia of adult male dissected from pupa (3 "0"-6D). All pupae of Accession 3 "0" were collected with the holotype; the pupal cases and the cocoons are preserved in alcohol. One pupa (6W-11), collected in the Río Patanatic #3, Panajachel, Sololá, on March 16, 1949, by Adán Flores M. and Jaime Rosales G.; slides prepared of genitalia, legs, head and bucco-pharyngeal apparatus of the adult female extracted from pupal case; case and cocoon preserved in alcohol. One pupa (6W-10) collected with last-mentioned pupa. Four pupae (5V-11) collected with allotype. Three pupae (5Y-9) collected in a stream just beyond San Carlos Sija, between Quezaltenango and Huehuetenango (Route #9), on December 15, 1948, by Adalberto Girón, Vicente Castellanos, and J. Onofre Ochoa A.

Holotype and allotype in collection of the United States National Museum; paratypes in collection of author.

Species dedicated to my wife, who has unselfishly helped to make this work possible.

Simulium (Hearlea) nigricornis, new species

To date, only five pupae of this species have been found. Slides have been prepared of the male genitalia, the female genitalia (cercus, anal lobe, and a part of the genital fork), the head and bucco-pharyngeal apparatus of the female. The adults were secured by dissecting them from within the pupal skins. The condition of the slide material and the lack of naturally emerged adults permits only the partial description given below.

Male.—Genitalia: Sidepiece broader than long with extremely prominent dome-shaped extension from the inner, posterior corner of the dorsal surface; extension so pronounced that it gives the sidepiece an appearance of being pentagonal. Clasper long and narrow, with well-developed apical spine arising from short longitudinal furrow near its apex (fig. 15). Adminiculum with main body broader than long; general shape quadrangular with all margins rounded; basal processes broad and heavily sclerotized throughout, equal in length to the body of the adminiculum; apical margin of adminiculum in the form of two rounded, lateral expansions, between which projects a median, finger-like extension clothed with curled hairs; on the ventral surface of the adminiculum, extending anteriorly from the median prolongation, there is a moderately pronounced keel which reaches the anterior margin; keel with row of hairs on both edges; strong, stout spine present on each side of ventral surface (fig. 16). Adminicular arm heavily sclerotized, with two semicircular, hyaline, chitinized processes near its attachment to the lateral plate and three rather blunt teeth at its distal end; lateral plate hyaline, without wrinkles, triangular in shape (fig. 17).

Female.—Dichoptic. Antenna 11-segmented, not strongly tapered, the third segment equal in length to the fourth and fifth measured together. Bucco-pharyngeal apparatus simple, the lateral processes well sclerotized, and with a definite indentation in the margin of the inner space. Fronto-ocular triangle 32 μ high and 52 μ wide at base.
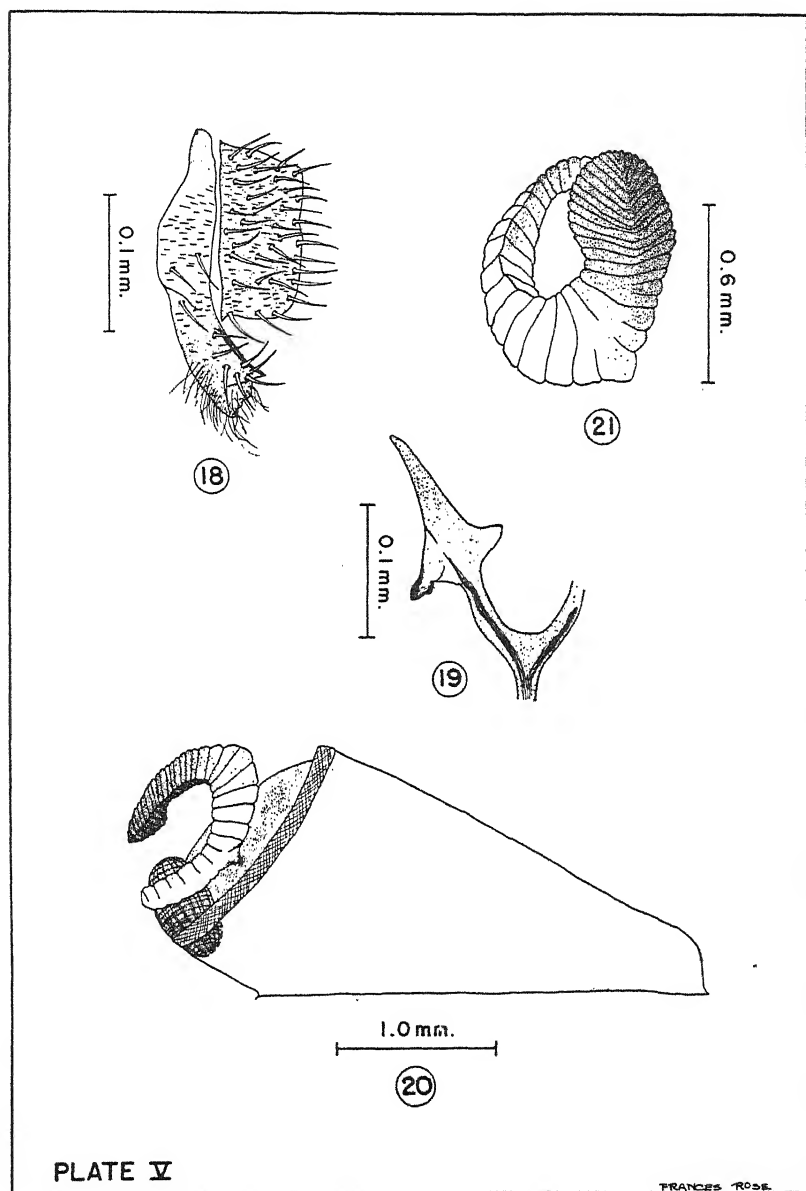
Simulium (Hearlea) nigricornis, n. sp. Fig. 18. Cercus and anal lobe of female. Fig. 19. Part of genital fork of female. Fig. 20. Cocoon with enclosed pupa (in profile). Fig. 21. Pupal respiratory filament of left side (dorsal view).

Genitalia: Cercus quadrangular, higher than broad, clothed with numerous spines and with minute, appressed hairs.   Anal lobe elongate, extending ventrad beyond the ventral border of the cercus; with minute, appressed hairs over entire surface and stout spines distributed sparsely only on ventral half; anterior ventral angle clothed with numerous fine hairs (fig. 18).   Genital rod with apical expansions triangular, only the external basal angle rather heavily sclerotized and pointed (fig. 19).

Pupa.—Cocoon: Dorsal slope, 3.0 mm.; longest dimension, 3.8 mm.; widest dimension, 1.3 mm.   Case simple, with very fine texture and with short anterior collar: rim around anterior aperture thickened (fig. 20).

Filaments: The respiratory apparatus of each side is comprised of a dorsal and lateroventral element, both appearing horn-like; pseudo-articulations of lateroventral element simple; those of dorsal element, when viewed from above, apparently radiating from the midline toward the lateral and anterior margins; dorsal element extremely broad, appressed dorsoventrally, and black along the distal three-fourths of its length (fig. 21).

This species most resembles *Simulium (Hearlea) ethelae* Dalmat in the general form of its cocoon and in the form of the genital structures of the male.   However, it can be distinguished from *ethelae* by the following characters: The relatively shorter clasper; the more irregular shape of the sidepiece; the presence of a median, haired prolongation of the apical margin of the adminiculum; lack of minute hairs investing ventral surface of adminiculum but with one long spine on each side; longer, more extensively sclerotized basal processes of adminiculum; lack of wing-like expansions on outer face of basal processes; triangular shape of lateral plate; and the presence of two semicircular structures near attachment of the adminicular arms to the lateral plate.   *S. (H.) nigricornis* can be distinguished from all other members of this subgenus which have horn-like respiratory filaments by the short, very broad form of the dorsal element of its respiratory apparatus, the type of pseudo-articulation it possesses, and the black coloration at its distal end.

Ecological Notes.—*Simulium (Hearlea) nigricornis* has been found in only two streams, Río Laguneta, Finca Tehuyá Luch, and Río Costita, Finca La Providencia, both in the municipality of Acatenango (Chimaltenango, Guatemala).   These streams flow along the Pacific slope of the Volcano Acatenango at an altitude ranging from 4000 to 5000 feet. The streams are approximately two feet wide, one inch deep, with temperatures varying between 15° C. and 19° C., the pH, 7.2, and the current speed, between 9 inches per second and 19 inches per second. The collecting spots were usually shaded by trees and shrubs and in all cases, the stream bed was composed of sand, small and large stónes, and much emergent vegetation.   The pupae were always collected on large stones and rocks.   All collections were made during the dry months from February to April.   Other species found in the same streams are: *S. capricornis* de León, *smarti* Vargas, and *rubicundulum* Knab.

Types.—*Holotype:* Male (Accession Acat. 589-8) dissected from pupal skin; pupa collected in the Río Laguneta, Finca Tehuyá Luch, Acatenango, Chimaltenango, on February 26, 1949, by Carlos R.

Santizo P. and Juan Marroquín G.; genitalia mounted on slide, remainder of adult discarded; pupal skin and cocoon in alcohol. *Allotype:* Female (Accession Acat. 589-8A) dissected from pupal skin; pupa collected with holotype: slides prepared of head, bucco-pharyngeal apparatus, wings, legs, and genitalia; pupal skin and cocoon preserved in alcohol. *Paratypes:* One pupa (Acat. 590-11) collected at type locality on March 23, 1949, by Daniel Luch. One pupa (Acat. 667-3) collected at type locality on March 28, 1949, by José H. Rosales G. and Daniel Luch. One pupa (Acat. 604-16) collected in the Río Costita, Finca La Providencia, Acatenango, on March 14, 1949, by Domingo Montúfar and Daniel Luch. *Paratype* (Acat. 604-16) in the collection of the United States National Museum; holotype, allotype, and all other paratypes in collection of author.

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THE MODE OF ACTION OF ORGANIC INSECTICIDES, by ROBERT L. METCALF. Review No. 1, (1948), 84 pages. Chemical Biological Coordination Center, National Research Council, Washington, D. C. Price, $1.00.

The author has collected and carefully arranged information from 300 critically selected papers relating to the subject of this timely review. "The material has been organized into nine chapters, each dealing with a recognized insecticide or class of insecticides. A brief review of the chemistry of each material has been presented in order to make the following discussion of toxicological, physiological, and biochemical information more intelligible." The entrance of insecticides into the insect body and theories of toxic action are considered.

It is not feasible in a brief review of Dr. Metcalf's publication to enter in any detail into a discussion of the subject matter, for a large amount of factual information is packed into the text and its 32 tables. The experimental entomologists and investigators in other fields who are actively concerned with the mode of action of drugs and poisons will find this review valuable, and the more casual scientific reader who may wish to become more familiar with recent trends in this entomological area will find its perusal well worth while.

The critical handling of the subject matter is evident in the manner of its presentation. The author wisely has refrained from attempting to present the reader with ultimate conclusions as to mode of action. The thoughtful reader very likely will be left with a healthy appreciation of the current need for much more fundamental research on the problems of how insecticides kill, problems of such ultimate significance to those concerned with the control of insect pests.

The author, who prepared this review at the request of the Entomology Subcommittee of the Chemical-Biological Coordination Center, is to be congratulated upon having accomplished a significant undertaking in a thoroughly competent manner.—J. F. YEAGER.

LONGEVITY IN THE ADULT WORKER HONEYBEE

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Scattered allusions to the longevity of insects are to be found as concomitant data in studies of widely varying kinds. Riley (1895) gave the life expectancy of the worker bee in the summer season as three weeks, as compared with a maximum of eight months over the winter months. Demuth (1926) suggested values of six to ten weeks for summer longevity as contrasted to a winter longevity of six to eight months for the same insect. Milum (1931) gave as the life span of the adult worker six to eight weeks for summer months and six to eight months for winter months. In an experiment on the change in the weight and nitrogen content of worker bees, Haydak (1937) was able to take a final sample as late as 236 days after emergence as an adult, for bees kept indoors on a protein-free diet. Howard (1939) cited a report by Farrar of marked bees having been kept alive up to 320 days, but gave the average longevity of the worker bee as generally being from three to eight months. Phillips (1939), an acknowledged authority on the honeybee and apiculture in general, stated that the honeybee worker can live six to ten weeks during the summer season and as long as six or more months during winter months.

In a study on the physiology of aging of the adult worker honeybee,[2] some interesting facts on the longevity of worker bees under conditions of normal activity of the hive, and of reduced indoor activity, were disclosed.

Newly-emerged worker bees were marked for future identification with colored lacquer and introduced into a normally-functioning hive in the apiary of the University of Minnesota. For indoor study, marked bees were similarly introduced into two large screen cages[3] provided with a plentiful supply of honey, pollen and water. Each cage was exposed to a 100-watt incandescent lamp day and night to help shorten the duration of the experiment. Although bees were removed for the physiological-histological studies (as seen in Table I), these constituted only a small portion of the total number, over 90% of the original number of bees being left untouched to die a "natural" death. Table I shows that final sampling, determined by the availability of bees for study, was made after 51 days in the case of outdoor bees and after 63 and 73 days for the two indoor cases, respectively. Obviously, then, the longevity of the bees would exceed these periods by not many

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more than a few days, the final sampling being determined by the observed rapid rate of dying-off as the populations became very low. Moreover, in all three cases, the bees in the final samples were of comparable ages, as indicated also in Table I by cell counts for representative sections of the worker bee brain, the degree of degeneration of brain cells being used as a criterion for the extent of senescence (Hodge, 1894; Phillips, 1939).

Several of the individual workers cited earlier stress the fact that length of life is dependent upon the amount of work which worker bees are called upon to perform. Bees emerging late in the fall, when brood-rearing is being rapidly reduced to a minimum, and performing a minimum of field duties during the winter months (in the northern climates) can thus live to a ripe old age of six to eight months. The summer worker rarely lasts beyond six weeks to two months during the height of brood-rearing and the honeyflow, and, indeed, most

TABLE I

Statistics on the Longevity of Worker Honeybees

Experiment	Outdoor (Hive) Bees	Indoor Bees Cage A	Indoor Bees Cage B
Original number of bees....................	2700	1250	2500
Total number of bees removed*...........	176	92	120
Number of bees remaining at final sampling	11	17	35
Average age in days, at last removal......	51	63	73
Average nerve cell count†................	325	351	341

*Total number removed for histological and physiological study.
†Made at two different levels of the bee brain.

reportedly die while on flights in the performance of field duties, literally in "harness." The data of the present report tend to corroborate in a roughly quantitative fashion the observations of apiculturists, as far as outdoor, hive bees are concerned. It is interesting that the indoor bees, despite forced activity by the stimulation of artificial lighting, nevertheless seem to be under reduced pressure, insofar as activity and resulting aging are concerned. Apparently, reduced range of flight due to the relatively small size of the cage (see footnote 3), and the lack of demands which a normally functioning hive makes upon the worker in the form of hive and field duties, result in a somewhat slower pace in activities and senescence as well. An interesting additional experiment might have been made, with the use of a cage which was only exposed to light for a shorter period. In this connection, Phillips (1922) found that completely starved bees lived an average of "2.1934" days for bees without any light at all, "1.2261" days under conditions of intermittent, diffuse lighting conditions, and only "1.1293" days under conditions of continued exposure to light. This indicates the extent to which activity as enhanced by increased hours of light stimulation affects longevity in the worker honeybee.

SUMMARY

By means of marked bees introduced into a normally-functioning hive, the average longevity of field bees during the middle and late spring months in Minnesota was found to be slightly more than 51 days. This figure compares favorably with values cited for different workers. For bees maintained indoors in cages, exposed to continuous artificial lighting 24 hours a day, longevity was two to three weeks longer than for outdoor bees.

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INSECTS AFFECTING FOREST PRODUCTS AND OTHER MATERIALS, by W. J. CHAMBERLIN. ix+159 pages, 101 figures. Lithoprinted. O. S. C. Cooperative Association, Corvallis, Ore., 1949. Price, $2.75.

The subject of insect damage to timber and timber products, raw and finished, has not previously been treated in book form, and considerations of this topic in texts in forest entomology and in original sources have been either brief, fragmentary, or both. In the present work, Dr. Chamberlin attempts to give an exposition of this subject, in not too technical language, for the use of foresters, structural and highway engineers, electrical engineers, and others who have need of such information. The forest entomologist and the teacher of forest entomology will find the work very useful.

After a brief introduction, the orders Isoptera (pp. 11–27), Lepidoptera (pp. 28–38), Coleoptera (pp. 39–119), Hymenoptera (pp. 120–127) and Diptera (pp. 128–132) are discussed in relation to direct damage to timber or timber products or in relation to feeding habits that would result indirectly in such damage. Control considerations are included, and lists of citations are appended to each section. A chapter on insects attacking metals (pp. 133–135), one on marine borers (pp. 136–147), and a general bibliography (*sic!*) on Coleoptera injurious to forest products (pp. 147–151) complete the work.

Useful as this work will be, it suffers from several shortcomings. The line-drawing illustrations as a whole reproduced fairly satisfactorily, but some of the photographic illustrations are so poor as to be worthless. Some inaccuracies are rather dismaying: for example, the reference (p. 1) to the Mollusca as a "Class" (on a par with the Crustacea and Insecta), and the statement that some flies have the antennae "reduced to mere bristles" (p. 5), that in the Lepidoptera "the fore wings are larger than the hind wings;" and that in dipterous larva the mouth parts are lacking and "food is assimilated osmotically through the skin." These errors arise through attempts at oversimplification or overgeneralization, but they are nevertheless errors. Better editing would also have corrected numerous misspellings and typographical errors.—M. T. J.

A NEW BAETIS FROM MICHIGAN
(Ephemeroptera)[1]

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The writer spent the period May 1 to October 19, 1948, in a temporary laboratory beside the Au Sable River in Crawford County, Michigan, where he maintained continuous observations on the aquatic insect fauna.   Among a number of novelties obtained during the course of this study was the *Baetis* described below.   Nymphs first attracted attention in collections made in mid-August.   They grew rapidly thereafter, and subimagoes began to emerge from the stream and from laboratory rearing containers on September 11.   Emergence was heaviest during the period October 1 to 3; no adults were taken after October 13.

The ecological and faunistic aspects of the collection site will be discussed more fully elsewhere.   It may be sufficient here to mention that the Au Sable River is a hard-water stream deriving almost all of its volume from spring seepages and tributaries; at the collection site it is about 80 feet wide and in midstream flows at a rate of 2.5 to 3.0 feet per second over a bottom of mixed glacial gravel and sand.   It is regarded as one of the most productive trout streams in the state.

Baetis hiemalis new species

Male imago.—Length of body 8 mm., of forewing 8.5 mm.   In life, the turbinate eyes (fig. 1) are a brilliant, glowing orange; in alcoholic material they are a subdued yellowish brown, while in dried specimens their color changes to a dark reddish purple.   In living and in alcoholic examples the bases of the translucent, faintly amber ocelli are black, the head between the ocelli and eyes is smoky brown with a narrow white area contiguous to the anteromesal margin of the turbinate eyes, the antennae and ventral surface of the head are smoky brown; in dried specimens all of these areas and structures range from piceous to black.

The thorax in life is shining piceous with purplish reflections, relieved by marginal white spots on the prescutum and by dilute grayish brown on the pleural folds.   In alcoholic material, fading reduces the color of the notum to dark brown, and brings into sharper relief the pale marginal markings along the prescutum, scutum and scutellum, and on the pleural folds.   In dried specimens the thorax is predominantly shining black, with paler areas changed to a deep reddish purple. Legs of living and dried specimens are amber, the tibiae and femora

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[1]Contribution from the Michigan Institute for Fisheries Research.

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suffused with smoky gray; in alcoholic material the legs fade to grayish white. Wings are hyaline, the venation pale amber, paired marginal intercalaries between all longitudinal veins of forewing from Sc to Cu_1; hind wing (fig. 1) with costal projection prominent, truncate.

The abdomen in living specimens is piceous with purplish reflections, dorsally about the same color value as the thorax, ventrally slightly paler; in pinned specimens the color fades to uniform medium brown dorsally, pale olive ventrally, with dark tracheal arms visible in the pleural region; in alcoholic material the abdominal tergites appear dilute reddish brown and an obscure pale mid-dorsal line is revealed, while the sternites become smoky amber except for the 9th sternite and forceps bases, which remain reddish brown, and alabaster appears in the pleural region of segments 7 and 8.   Claspers and "penis sheaths"
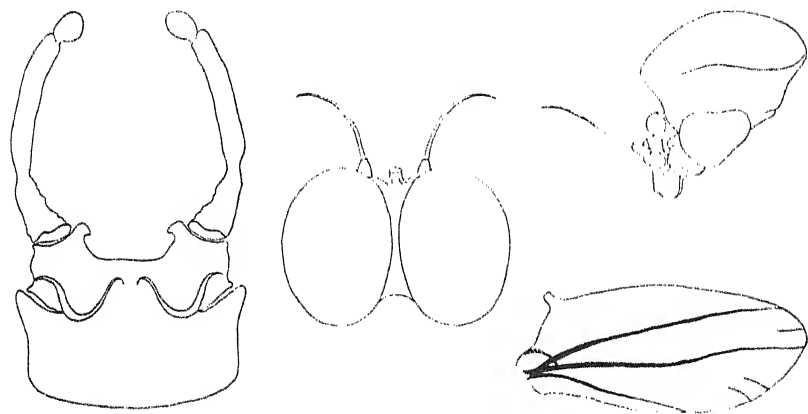
Fig. 1. *Baetis hiemalis:* Left, male genitalia (× 48); center, head of male, dorsal aspect (× 23); upper right, head of male, lateral aspect (× 23); lower right, hind wing of male (× 23).

are shown in figure 1.   The caudal filaments, smoky amber in living and pinned specimens, fade to pearly white in alcoholic examples, and are always unringed.

Female imago.—Length of body 8 mm., of fore wing 9.5 mm. Closely resembling male in ambisexual characters except as follows in alcoholic specimens: the entire head dorsum is pale pinkish gray with the bases of the ocelli broadly black and the occipital margin medium brown; the fore wing is longer in relation to body length than in the male (see measurements); and in the egg-swollen abdomen the tracheal trunks ramifying from the spiracles show more extensively than in the male.

Holotype, male.—Michigan, Crawford County, T. 26 N., R. 2 W., Section 12, Au Sable River, J. W. Leonard and F. A. Leonard, October 3, 1948; a reared specimen preserved in alcohol together with its nymphal and subimaginal exuviae, genitalia in slide mount.

Allotype, female.—Same data as for holotype, but appeared as imago October 1, 1948; preserved in alcohol intact.
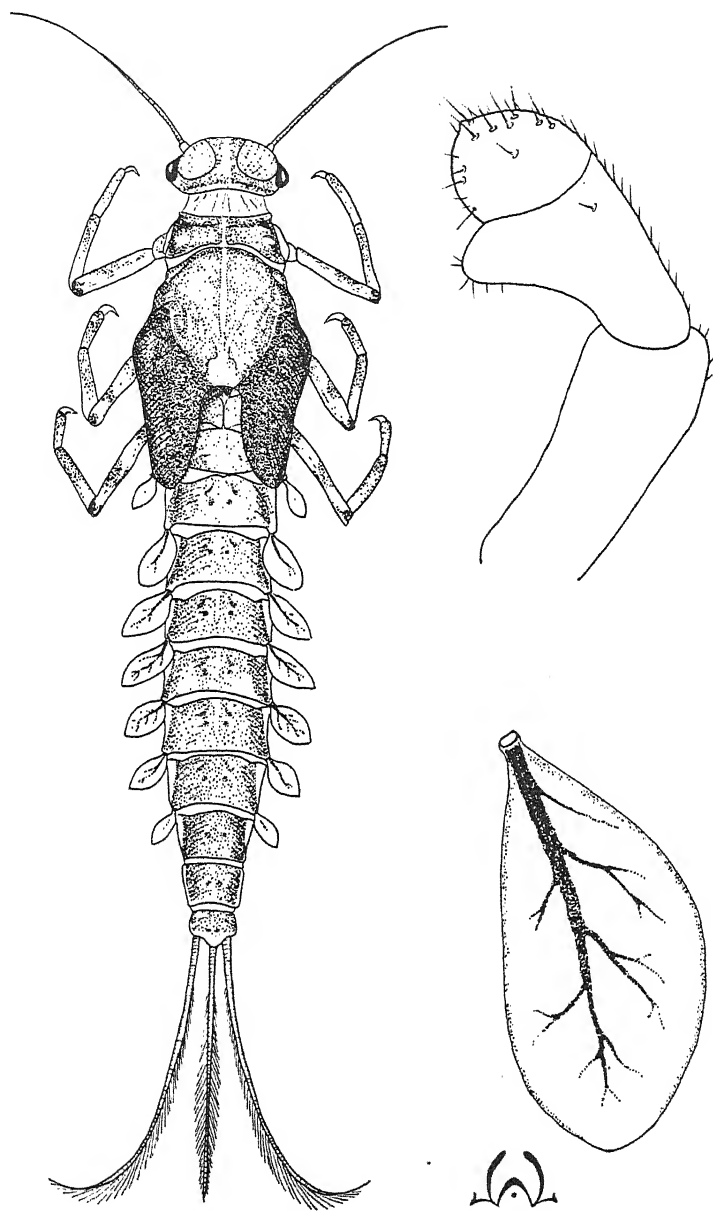
Baetis hiemalis: Left, mature male nymph ($\times$ 12); upper right, labial palp of nymph ($\times$ 87); lower right, fourth gill ($\times$ 65).

Paratypes (all taken in 1948 at same locality and by same collectors as holotype). Pinned.—October 13, 1 male, 1 female, reared. In alcohol, reared, with nymphal exuviae.—September 11, 1 female; September 14, 1 male, 1 female; September 16, 2 females; September 17, 2 females; October 1, 1 male, 3 females; October 2, 1 male, 2 females; October 3, 4 males. Not reared.—September 22, 1 male; September 29, 1 male.

All types are deposited in the collection of the Insect Division, University of Michigan Museum of Zoology.

Nymph.—Length of body 9–10 mm. General configuration, dorsal markings, and labial palp as shown in Plate I. Ground color very dark olive, lighter areas medium brown (body) to grayish white (legs); narrow middorsal pale stripe clearly defined and unbroken on head and thoracic nota, apically interrupted on abdominal tergites 1 to 6 and 9 to 10, almost wholly obscured on 7 to 8. Venter of body paler than dorsum, lightly sclerotized portions of thoracic sterna, and abdominal sternite 1, grayish white, remainder of venter medium olive; abdominal sternites with paired median dark dots just apical to paired median subreniform dark spots, similar to markings of tergites (Plate I), and with a narrow, transverse pale mark about one-third the distance from the apex of each sternite except 10 originating on either side of the mid-ventral line and extending laterally to join the pale, semi-transparent lateral borders of the segments. Gills (Plate I) with darkened margins, and with rather conspicuous dark tracheae in all except first and last pairs, in which tracheae are rather faint. Caudal filaments unbanded, darker basally, fading to grayish white apically, laterals 23% longer than median.

Nymphs.—Same locality and collectors as holotype, September 16, 16 nymphs; October 2, 1 nymph; October 3, 2 nymphs; all 1948.

When nymphs of this species first attracted attention, in collections made about a month before emergence started, they were tentatively referred to *Baetis brunneicolor* McDunnough. As growth proceeded, their size, pattern, and certain morphological characters including gills, labial palp, and length of lateral caudal filaments in relation to the middle filament removed them from this assignment. Mature nymphs suggested *B. hudsonicus*, described by Ide (1937) from nymphal material. Significant differences between *hiemalis* and *hudsonicus* were apparent, however. Characters of mature *hiemalis* nymphs are tabulated with corresponding characters of *hudsonicus* as described by Ide (1937).

	hiemalis	*hudsonicus*
Body length:	9–10 mm.	7.5–8.5 mm.
Pronotum:	With distinct pattern.	"evenly brown."
Legs:	Apical third of femora pale, with dark median band and piceous apical stripe.	"evenly suffused with brown."
Abdominal segment 1:	Same color as remaining segments.	"segment 1 pale."
Gills:	Tracheae distinct (resembling *brunneicolor*).	". . . without conspicuous tracheae."
Caudal filaments:	Laterals 23% longer than median.	"caudal filaments subequal, median rather longer."

The labial palp of *hiemalis* (Plate I) closely resembles that of *hudsonicus* as figured by Ide (1937). On morphological grounds, *hiemalis* would seem to be closely related to *hudsonicus* and only slightly less so to *brunneicolor*. Its size, morphological differences, and very late season of emergence, should assist in differentiating it from these close congeners.

Mature nymphs of *hiemalis* were collected most plentifully in areas of shallow, sluggish flow near the edge of the river, where they clung to submerged vegetation. During the emergence period air temperatures dropped as low as 24° F. at night; the subimaginal stage lasted 48 to 72 hours.

The assistance of Dr. B. D. Burks, who checked the *hiemalis* material and concurred in the view that it represented an undescribed species, is gratefully acknowledged.

REFERENCE

Ide, F. P. 1937. Descriptions of Eastern North American Species of Baetine Mayflies with particular reference to the Nymphal Stages. Canadian Entomologist, 69: 219–231, 235–243, pls. 8–12.

PHYSIOLOGIE DE L'INSECTE, by Remy Chauvin. 619 pages. Institute Nationale de la Recherche Agronomique, Paris. 1949. Price, 2500 fr.

This is a much-needed work on the subject, bringing up to date the literature of the field of insect physiology. In the ten years which have elapsed since the appearance of the pioneer and only work on the subject of insect physiology, by Dr. Wigglesworth, tremendous advances have been made in methods and techniques in biophysics and biochemistry. These have gradually been adapted, by general physiologists as well as insect physiologists, to studies on the physiology of insects (*e.g.*, the use of isotopes in physiological studies, studies involving the electron microscope, etc.). Not only has the author included findings based on biochemical methods especially, but he has also included actual descriptions of methods and apparatus, the latter occasionally illustrated. The work is conventionally divided into nine chapters beginning with the [in]tegument and ending with reproduction. An excellent treatment of insect nutrition and of the lesser-known sex physiology studies of von Frisch, as well as a section described by the author as "ecophysiology," are included. The last-mentioned will prove of interest to ecologists interested in laboratory bases for environmental influences on insect growth. The general treatment of the modern concept of cuticle composition, as expounded by A. G. Richards, is especially commendable, since the now refuted concept of a chitinous base for insect cuticle is still being taught by some contemporary entomologists.

The excellent bibliography at the end of several chapters is marked with more than infrequent inconsistencies in the titles of English-written journals. The Journal of Cellular and Comparative Physiology, for example, is written in a least four different fashions, capital letters for the adjectival words being included or omitted inconsistently from time to time. The index also leaves much to be desired, since its arrangement according to generic and family names makes the finding of material quite difficult. This is paradoxical, since the arrangement of the chapters and content is in the classical manner, *i.e.*, according to the physiology of the various organ systems.

Aside from occasional apparently typographical errors in the text, the book is well-written and reads easily. As such it is a work which could be used as a basic text in Insect Physiology by students capable of handling the language.

—M. Rockstein.

THE ENTOMOLOGICAL SOCIETY OF AMERICA
PROCEEDINGS OF THE FORTY-FOURTH ANNUAL MEETING

Tampa, Florida, December 13-16, 1949

The Entomological Society of America held its forty-fourth annual meeting Tuesday through Friday, December 13-16, 1949, in conjunction with the annual meeting of the American Association of Economic Entomologists. Headquarters were at the Hillsboro Hotel. Attendance for the combined meetings totaled over 600. Joint sessions were held with the American Association of Economic Entomologists and the Florida Entomological Society.

The Tampa Chamber of Commerce, cooperating with other Florida groups, carried out an extensive program for the entertainment of the ladies. This included functions at the University of Tampa Women's Club and at the Yacht Club, and tours of the various scenic spots and points of interest.

The following sessions of the Society were held:

Tuesday, December 13

8:30 A. M.—Registration.

10:00 A. M.—Joint Session. President Peterson opened the Session with a word of welcome to the assembled entomologists and introduced the President of the A.A.E.E., A. M. Boyce, who delivered the address of the President on the subject"Citrus Insects."

1:30 P. M.—General Session; Presentation of Papers. President Peterson called the meeting to order and appointed the following committees:
> *Nominating Committee:* C. W. SABROSKY, CHARLES MICHENER and C. E. MICKEL, Chairman.
> *Resolutions Committee:* EARL PRITCHARD, J. C. BRADLEY, and Z. P. METCALF, Chairman.

Wednesday, December 14

8:30 A. M.—Joint Session—Special Topics. Presiding Officers, Alvah Peterson, President, E.S.A., and C. P. Clausen, First Vice-President, A.A.E.E. At this session was given the invitational public address of the E.S.A. entitled "Present Status of the Knowledge of Immature Insects," by William H. Anderson.

1:30 P. M.—Physiology Section; Presentation of Papers. Chairman, A Glenn Richards, Jr.; Vice-Chairman, Leigh Chadwick; Secretary, R. L. Patton.

1:30 P. M.—Taxonomy Section; Presentation of Papers. Chairman, C. E. Mickel; Vice-Chairman, A. N. Tissot; Secretary, C. W. Sabrosky.

6:00 P. M.—Social and Cocktail Hour.

7:30 P. M.—Entomologists' Dinner, followed by entertainment and dancing.

Thursday, December 15

9:00 A. M.—Taxonomy Section; Symposium on Entomology and Zoogeography.   Chairman, C. E. Mickel.

1:30 P. M.—Joint Session—Teaching Section of A.A.E.E., Chairman, W. P. Hayes; Secretary, Thomas C. Watkins.

1:30 P. M.—Physiology Section; Symposium on Resistance.   R. L. Patton, presiding.

Friday, December 16

1:30 P. M.—Joint Session with Florida Entomological Society.   Field trip to Everglades.   Lewis Berner in charge.

8:00 P. M.—Entomologists' Night.

Saturday, December 17

9:00 A. M.—Bus Tour of Tampa and vicinity.

BUSINESS SESSION

President Peterson called the meeting to order and asked for the report of the Secretary.

REPORT OF THE SECRETARY

Executive Committee Activities.

In May, the proposal was considered by the Executive Committee that some thought be given to a possible unification of the two national entomological societies.   It was voted that an exploratory probe of the entire situation be undertaken and that a committee be appointed to look into the merits of this situation and explore the possibilities of a satisfactory unified organization which might be considered.   President Peterson appointed the following committee: E. G. LINSLEY, C. E. MICKEL, C. F. W. MUESEBECK, Chairman.

Twenty new members were elected by mail ballot.

President Peterson appointed a Membership Committee composed of R. L. USINGER, HENRY DIETRICH, LEWIS BERNER, WILLIAM ANDERSON, and W. P. HAYES, Chairman.

Annual Executive Committee Meeting.

A special meeting of the Executive Committee was held at 7:30 p. m., December 12, to discuss the report of the Committee on Possible Consolidation of the Entomological Societies.   Mr. Muesebeck presented the Committee's report which was discussed at some length.   After this the Executive Committee met with the Executive Committee of the A.A.E.E. to talk over various points raised in the discussion.   It was unanimously agreed that the two committees be continued as a single, joint committee and be instructed to draw up the working proposal which could be submitted to the membership for consideration at the next annual meeting.   B. A. PORTER was named as chairman of the joint Committee.

The regular annual meeting of the Executive Committee was held the evening of December 13 with the following members present: ALVAH PETERSON, A. G. RICHARDS, M. T. JAMES, O. E. TAUBER, E. G. LINSLEY, W. GERTSCH, H. H. ROSS, and alternates Z. P. METCALF and C. E. MICKEL.

1.   Fifty new members were elected to the Society.

2.   The following members have resigned during the year: TREVOR KINCAID, C. H. HADLEY, CHARLES T. GREENE, R. V. CONNIN, FRANK JOHNSON, A. F. WEISGERBER, A. E. BADERTSCHER, MRS. W. M. LEWIS, E. J. ANDERSON, W. E. BLAUVELT, J. D.

JONES, G. A. DEAN, A. F. BURGESS, DR. MIROYLANNIS, ROY W. RINGS, J. C. REDD, MABEL COLCORD, TAMARATH K. YOLLES, SARAH E. JONES, H. M. GELFAND, C. A. DAMBACH, E. R. BUCKELL, K. B. M. CROOKS, and S. A. WATSON.

The following members have been dropped from membership because of failure to pay dues or because they cannot be reached: W. H. BALL, H. F. BARNES, B. F. DRIGGERS, W. W. GIBSON, R. D. GLASGOW, RAYMOND GOELBERT, G. B. HARSTON, P. E. HERING, HOWARD HINTON, T. K. JUST, B. KRAFCHICK, A. H. MADDEN, D. C. PARMAN, EDWARD DEL PONTE, R. E. RIEDER, TAKAHISA SAWAMOTA, M. A. WEYMARN, EDWARD H. WILSON.

3. It was moved to award DR. KENNEDY a life membership in the Society in gratitude for his many years of service as Associate Editor and Managing Editor of the Annals.

4. It was moved that no action be taken this year on election of Fellows.

5. The Society has suffered the loss by death of the following members: REV. MODESTUS WIRTNER, F. B. ISLEY, W. B. HERMS, A. AVINOFF, and FILIPPO SILVESTRI. After the reading of the names, the members stood in silence in memory of the departed.

6. The following were elected to fill vacancies in the Thomas Say Foundation: WILLIS GERTSCH, ALAN STONE.

7. The following were elected to fill vacancies in the Editorial Board: P. O. RITCHER, A. B. KLOTS, J. N. KNULL.

8. It was moved to contribute $100 to the support of Zoological Record.

9. The next annual meetings will be held at Denver, Colorado, December 18-21, 1950, in conjunction with the A.A.E.E.

10. The following were appointed as officers of the Physiology Section: Chairman, R. L. PATTON; Vice-Chairman, O. E. TAUBER; Secretary, LEIGH CHADWICK.

11. The following were appointed as officers of the Taxonomy Section: Chairman, C. W. SABROSKY; Vice-Chairman, R. L. USINGER; Secretary, C. D. MICHENER.

12. It was moved that DR. J. C. BRADLEY be appointed a representative of this Society to promote attendance of American entomologists at the Ninth Entomological Congress at Amsterdam; further that a notice of the Congress be published in the Annals.

It was moved that the Treasurer be instructed to suspend acceptance of new life memberships until the question of amalgamation be settled.

<div align="center">Respectfully submitted,</div>

<div align="right">HERBERT H. ROSS, *Secretary*.</div>

On motion, the Secretary's Report was adopted as read.

<div align="center">TREASURER'S REPORT</div>

<div align="center">DECEMBER 4, 1948, TO DECEMBER 6, 1949</div>

<div align="center">CURRENT FUND</div>

Balance on hand December 4, 1948 .... $ 4,477.64
Receipts 5,581.06

    Total $10,058.70

<div align="center">EXPENDITURES</div>

Annals (5 numbers) .... $ 6,486.04
Expenses of Secretary-Treasurer's Office, including cost of New York
    meetings 568.72
Bank charges 1.27
Travel expenses of Managing Editor 270.40
To Zoological Society of London 100.05
To Insect Physiology Foundation 1,000.00

    Total .... $ 8,426.48
Balance in Bank, December 6, 1949 .... 1,632.22

    Total $10,058.70

PERMANENT FUND

Balance on hand December 4, 1948................................$ 4,625.54
Interest and Coupons.. 11.44

Balance on hand December 6, 1949...............................$ 4,636.98
Liberty Bond.. 50.00

    Total...$ 4,686.98

TOTAL RESOURCES OF SOCIETY

Balance in Current Fund...$ 1,632.22
Balance in Permanent Fund....................................... 4,686.98

    Total...$ 6,319.20

Respectfully submitted,

HERBERT H. ROSS, *Treasurer.*

The Treasurer's Report was adopted subject to approval by the Auditing Committee.

REPORT OF THE MANAGING EDITOR

During the course of the year, we have succeeded in bringing the publication of the ANNALS approximately up to date. The June issue was delayed as a result of some reorganization in the offices of Spahr and Glenn, but the September issue appeared in early October and the December issue should appear in January or early February. The 1949 volume will total approximately 550 pages.

Printing costs have mounted to about $8.50 a page. We have investigated the possibility of lowering this cost without sacrificing quality in our publication, but have met with no success. The publishers are, however, furnishing us with a better grade of paper, which is smoother and a little whiter than in the past, and which will take illustrations, particularly half-tones, better. This should add to the permanent value of the ANNALS.

The matter of prompter publication remains a problem. There is on hand a sufficient number of acceptable manuscripts to fill the 1950 volume. On a whole, we are receiving high-quality manuscripts, and rejections are being made mainly on the basis of unsuitability to our editorial requirements. We now accept long manuscripts, that is, those of more than fifty printed pages, only if the author or his institution can pay the cost of publishing the pages in excess of fifty. There seem to be three courses open, so far as handling the backlog is concerned. One is to maintain the present policy, with the expectation of having constantly a year's backlog on hand, and consequently delaying publication of articles for that period of time; a second is to be more rigid in our editorial requirements; and a third is to increase our income through increased dues, and consequently to handle a greater volume of material with either longer or more frequently appearing issues.

On July 16, 1949, we signed a contract with University Microfilms, of Ann Arbor, Michigan, which would, in consideration of a 10% royalty of sales, permit that company to reproduce the ANNALS by microfilm, these microfilm copies to go only to *bona fide* subscribers, for their use only and not for resale. The intention of the contractor is to supply libraries with copies which they can maintain permanently, without cost of binding and with decreased storage costs. The contract may be terminated by either party on a year's notice. Dr. Ross and I both went over the material carefully and concluded that we would, at least, have nothing to lose. Any possible loss resulting from decreased sale in back copies should be offset by the royalties.

The progress of the ANNALS during the year has been due in no small part to the efficient work of Mrs. Helen Lanman in the Columbus office and Miss Doris Cripps in the mailing room, to the cooperation of the State College of Washington in granting me time for editorial work and to the part-time secretary, Miss Arden Sudhoff, who has been employed for me, and to the aid I have received from members of the Editorial Board. The cooperation of our printers and engravers has added greatly to our operating efficiency this year.

The following is a financial report for the year.

<div align="center">

FINANCIAL REPORT

SEPTEMBER, 1948, TO NOVEMBER 15, 1949

RECEIPTS
</div>

Received from A. W. Lindsey, Sept.–Nov. 4, 1948	$ 936.94
Non-member subscriptions and sales from the Columbus office	2,117.97
From authors for cuts	768.68
University of Tennessee, cuts and reprints	14.07
University of Delaware, cuts, reprints, and publication costs	135.82
J. L. Gressitt, credit against cuts and reprint costs	20.00
Total	$3,993.48

<div align="center">DISBURSEMENTS</div>

Stationery and supplies	$ 116.84
Engraving	813.37
Express and postage	153.22
Stenographic and addressograph service	348.50
Refunds on subscriptions	6.75
To Spahr and Glenn; reprints, University of Tennessee and University of Delaware	14.08
Total	$1,452.76
Uncashed checks and cash on hand	6.90
Bank balance, First National Bank of Pullman	2,533.82
	$3,993.48

<div align="center">

Respectfully submitted,

MAURICE T. JAMES, *Managing Editor.*
</div>

This report was adopted subject to approval by the Auditing Committee.

<div align="center">

REPORT OF THE INSECT PHYSIOLOGY FOUNDATION
</div>

The Foundation's Subcommittee on Finances reported that financial support for the proposed Journal of Insect Physiology was becoming difficult to obtain. Because of this, it was the joint thought of both the Foundation and members of the Executive Committee that the Foundation be placed on a stand-by basis. Should later developments indicate a more favorable situation, the Committee is ready to function in support of the project. In the meantime, the funds in its account will be transferred back to the Secretary-Treasurer after this report is approved.

<div align="center">FINANCIAL REPORT</div>

On deposit, Champaign Co. Bank and Trust Co., December 2, 1948	$1,000.00
To stationery and supplies—Twin City Printing Co., January 20, 1949	55.00
Balance December 16, 1949	$ 945.00

<div align="center">

Respectfully submitted,

WILLIAM R. HORSFALL, *Editor,*

Proposed Journal of Insect Physiology.
</div>

On motion this report was adopted as read, subject to the approval of the Auditing Committee.

<div align="center">

REPORT OF AUDITING COMMITTEE
</div>

We, the undersigned members of the Auditing Committee, beg to make the following report concerning the accounts of the Society:

W. P. HAYES has examined the books of DR. H. H. ROSS, Treasurer of the Society, and has found them to be correct and properly balanced. He has also examined the accounts of W. R. HORSFALL, Editor of the Insect Physiology Foundation, and has found them to be correct and properly balanced.

MORRIS ROCKSTEIN has examined the accounts of the Managing Editor of the Annals and has likewise found them to be correct and properly balanced.

At the time this report was written the accounts of J. J. DAVIS, Treasurer of the Thomas Say Foundation, are not complete and an audit was not made. It should also be pointed out that an audit of these funds was not made for the previous year as noted by the Auditing Committee appointed last year.

Respectfully submitted,

MORRIS ROCKSTEIN,
H. O. DEAY,
W. P. HAYES, *Chairman.*

On motion, this report was adopted as read.

An oral report was given by DR. C. D. MICHENER on the Joint Committee on Entomological Nomenclature. Dr. Michener explained that the Committee was functioning as a service organization and undertaking a project regarding supergeneric names.

An oral report was given by DR. W. P. HAYES on activities of the Membership Committee. Dr. Hayes pointed out that his Committee had been able to increase the number of new members considerably over what would have been a normal number for the year. Dr. Mickel moved that the Committee be continued. The motion was carried.

Mr. Muesebeck reported for his Committee on the Unification of Entomological Societies. He explained the essential points of agreement that the Committees of the two Societies had reached and emphasized the fact that other matters needed further study and clarification. These points will be among the first matters to be considered by the newly formed Joint Committee. Many points were raised in discussion by members, and it was evident that the Committee had already been taking these into serious consideration.

It was resolved that the Executive Committee be requested to arrange for meetings of the Society in conjunction with other Zoological Societies at least once in three years, if at all possible. It was further resolved that the Executive Committee explore the possibility of meeting at some other time of year to enable more students and teachers to attend the meetings.

REPORT OF THE RESOLUTIONS COMMITTEE

Having had such a delightful meeting of the Entomological Society of America in Tampa, now therefore be it resolved:

1. That the Society express its thanks to the Tampa Terrace and Hillsboro Hotels and Masonic Lodge for their cooperation in making our meetings a success.

2. That the Society express its appreciation to William H. Anderson for his excellent summary, "Present Status of Knowledge of Immature Insects," as presented in the annual public address.

3. We would also acknowledge again the efficient service of our managing editor, MAURICE T. JAMES, and HERBERT H. Ross, both of whom have done most excellent work in the affairs of our Society. We would direct that a letter expressing our thanks for secretarial aid be sent to the proper authorities of the State College of Washington and the Illinois Natural History Survey.

4. We would acknowledge our appreciation to all of those who have labored to make this meeting not only a successful one, but also an enjoyable one. We would like therefore to thank the local arrangements committee, composed of W. B. GRESHAM, W. V. KING, LEWIS MAXWELL, RALPH L. MILLER, JOHN A. MULRENNAN, HERBERT SPENCER, W. L. THOMPSON, N. CLAIR VAN HORN, T. ROY YOUNG, and JOHN T. CREIGHTON, Chairman, for their untiring efforts in arranging such a fine program, and the Special Committee of the Florida Agricultural Research Institute, D. L. HAGADORN, G. D. SLOAN, PAUL E. KASPAR, J. K. SPARKMAN, and W. M. ROWE, Chairman, for the very enjoyable entertainment provided at the entomologists' dinner.

We would express our appreciation to the Subcommittee of the Local Arrangements Committee, composed of the wives of the members of the Local Arrangements Committee, headed by MRS. CREIGHTON, for the series of delightful occasions they arranged; and to LEWIS BERNER and the Florida Entomological Society for providing a trip to the Everglades for visiting Entomologists.

5.   Be it resolved that the Society note with sincere regret the loss of certain members by death during the past year, and we would suggest that an expression of our sympathy be sent to the families of the deceased.

Respectfully submitted,

A. EARL PRITCHARD,
J. CHESTER BRADLEY,
Z. P. METCALF, *Chairman.*

REPORT OF THE NOMINATING COMMITTEE

The Nominating Committee unanimously nominates:

For *President*..W. P. HAYES
    First Vice-President............................J. C. BEQUAERT
    Second Vice-President..........................S. E. FLANDERS
    Secretary-Treasurer................................H. H. ROSS

As members of the *Executive Committee*—M. H. HATCH, W. H. ANDERSON *Councilors to the American Association for the Advancement of Science*—J. F. YEAGER, 2-year term; A. E. EMERSON, 1-year term; T. H. HUBBELL, alternate.

Respectfully submitted,

CHARLES D. MICHENER,
CURTIS W. SABROSKY,
CLARENCE E. MICKEL, *Chairman.*

It was moved that the Secretary be instructed to cast a unanimous ballot for these officers.   Motion carried.

The meeting then adjourned.

REPORT OF THE JOINT COMMITTEE ON THE PREPARATION OF A HISTORY OF ENTOMOLOGY IN RELATION TO WORLD WAR II

Due to serious illness, it has not been possible for COLONEL E. C. CUSHING, general editor, to complete the "History of Entomology in Relation to World War II," as anticipated.   The preparation of this history is a project sponsored jointly by the American Association of Economic Entomologists and the Entomological Society of America.

Before becoming ill, Colonel Cushing conducted extensive research and accumulated much information, in addition to that supplied by the joint committee, which will aid in the completion of the project.

The general editor is anxious to resume active work and has reported to this committee that he hopes to complete the history by the summer of 1950.

Respectfully submitted,

RALPH W. BUNN,
STANLEY W. BROMLEY,
E. F. KNIPLING, *Co-Chairman,*
P. W. OMAN, *Chairman.*

THE NINTH INTERNATIONAL CONGRESS OF ENTOMOLOGY

"The Ninth International Congress of Entomology will be held August 17th–24th, 1951, at Amsterdam (Netherlands).   Entomologists wishing to receive programs and application forms are requested to communicate with the Secretariate, c. o. Physiologisch Laboratorium, 136 Rapenburgerstraat, Amsterdam, and with Professor J. C. Bradley, Department of Entomology, Cornell University, who is in charge of the Entomological Society Delegation and is the American representative on the Permanent Committee of these Congresses.

"Further communications will follow later in 1950."

BOOK NOTICES

WEBS IN THE WIND, by WINIFRED DUNCAN. xv+387 pages, 74 plates, 101 text figs., frontispiece. The Donald Press Co., New York. Price, $4.50.

This book is probably the only one in existence purporting to deal with the natural history of a group of organisms in which the great majority of the animals considered are not identified by the author and are neither described nor figured so that they may be recognized by anyone else. The author, by her own admission without previous knowledge of her subject, spent two years studying spiders and recording her observations. The book that resulted is a curious hodgepodge of misidentifications, misinterpretations and misconceptions.

The book is filled with sketches of spiders, webs, "houses," "hideouts" and other structures; but, so far as possessing any significance, the majority might just as well have been left out. Not being able to recognize the spiders she tries to discuss, the author provides such names of her own as, "Cream Dwarf Babies," "Mesh Potato Spider," "Dear little mother Epeira" or "Jack," "John," "Jerry" and "Jaqueline." Where she found the few technical names she often misapplies is perhaps explained in her statement (p. vi) that she "peeped into just one old spider book." Actually, however, she looked at several other books as indicated in her bibliography of 14 titles. Completely ignored were the hundreds of studies of spiders which might have disabused her of the idea that little work had been done in the field.

There are so many errors in the book that pages would be required simply to enumerate them. An explanation for some of them may possibly be found on Plate 8 which depicts a person looking at a web through the wrong end of a pair of field glasses.

The author can neither quote nor interpret correctly the statements of others, as may be seen on page 54 and again on page 98, where she puts words in the mouth of Henry C. McCook which he would never recognize as his own. Some other examples are as follows. Page 68: "The epigynum in males does not develop until after the last moult." The male, of course, has no such structure. Again, page 68: "The crustaceans who share their [spiders] extraordinary anatomical make-up," this in reference to the mating structures. Not so! Page 70: "Emerton, the Peckhams, Fabre, etc., used the word Epeiridae, to cover a whole order." Epeiridae is a family name and was so used. Page 101: The daddy-long-legs is described as having only four segments in the abdomen and with eyes raised like those of a crab, on tubercles. Many phalangids have more than four visible segments and the eyes of a crab are quite differently disposed. *Liphistius* is reported as found only in Sumatra but there are species of this genus in various parts of Malaya and Burma. Page 101: "The one real fossil spider that has been found, *Heptathela kimurai*." Hundreds of real fossil spiders have been found. Page 102: "The scorpions are members of the spider family and so are the king crabs (more exactly all three are of the order of Arachnids)." Wrong again! The arachnids constitute a *class* and the spiders, king crabs and scorpions all belong to different orders and, indeed, are often placed in distinct sub-classes, king crabs, sometimes, even in a different class. Figure 24, page 124, bears the legend, "Pholcus Eating a Lady Bug." Eating with what, the tip of the 4th leg? Page 360: The author believes she may have discovered daddy-long-legs that spin cocoons and guard egg-sacs. Arachnologists would very much like to see examples. Page 364: "The real Tarantula, is a member of the scorpion family, is perfectly flat, and smaller than a penny." There are three distinct errors here: first, the genus *Tarantula* is a tail-less whip scorpion of the order Pedipalpi; second, it is not perfectly flat; and third, a specimen before me could straddle a dinner plate. The word "tarantula," as a common name applied to the "big furry spider," is perfectly correct and has been in use for generations. Figure 70, page 284, is labeled, "Female *Micrathena* Walking." This is remarkable since the figure depicts a creature without legs. Page 366: In the solpugids, "as in the Pedipalps, the first pair of legs is attached . . . to the head-segment," an arrangement which the author regards as, "a curious variation on the leg theme." Very! Even some of the terms in the glossary are incorrectly defined: The epigynum is *not* the "sexual opening in both male and female." "Lung Books. Whitish plates . . . which cover the tracheal breathing tubes." Not so! Index,

page 383: *Leiobunum formosum* happens to be a daddy-long-legs, not a centipede. Page 376: The word is pedicel, not pedicle. And dozens of other errors in the names of spiders and other creatures.

How an editor could accept the manuscript for such a book and a publisher be found to print it, is beyond comprehension. The book is well printed on excellent paper and is attractively bound, and that is the most that can be said for it.—SHERMAN C. BISHOP.

STUDIES ON THE CENTRAL AND SYMPATHETIC NERVOUS SYSTEM
AND SOME SENSE ORGANS IN THE HEAD OF NEUROPTEROID
INSECTS, by KJELL EHNBOM. 162 pp., 142 figs. Opuscula Entomologica
Supplementum VIII, Entomological Society of Lund. 1948.

This is an extensive work which should prove a significant contribution to the comparative neurology as well as to the taxonomy of this group of insects. Special emphasis is laid upon the Trichoptera and Lepidoptera to which orders two chapters are devoted, representing 127 of the total (162) pages.

A student of Hanström, the author has written a monograph replete with excellent microphotographs of (original) histological material and several figures of whole brains reconstructed from sectioned material. The Mecoptera, Megaloptera and Neuroptera are treated only briefly in one short chapter. With major emphasis on histology, the author treats the Trichoptera and Lepidoptera under the divisions of the central and sympathetic system including the protocerebrum, deutocerebrum, and tritocerebrum, the supra- and suboesophageal ganglia, the corpora cardiaca, corpora allata, recurrent nerve, frontal and hypocerebral ganglia. A brief historical summary of the work to date on the neurology of the five orders mentioned is included. It is significant that this is the first piece of work which includes an extensive treatment of the morphology and histology of the central nervous system of the Trichoptera and the first investigation of the sympathetic system of this same order. Emphasis on the differences and similarities of the Trichoptera and Lepidoptera nervous systems is made from the point of view of the comparative morphologist as well as of students of phylogeny. The demonstrated parallelism in the anatomy of the nervous system of the Lepidoptera and Trichoptera helps to confirm the close phylogenetic juxtaposition into which these two orders have been placed by other anatomical and morphological similarities. This relationship is also emphasized in the comparisons of families within each of these two orders; *i.e.*, Trichoptera-like features of the nervous system of lepidopterous forms, and lepidopteran features of that of trichopteran genera.

Although this is a desirable addition to the library of the student of insect neurology primarily, it is a worthwhile supplement to the general body of knowledge which should also be helpful to workers interested in anatomical bases for neurophysiological and endocrinological investigations.—M. ROCKSTEIN.

ARQUIVOS DE ZOOLOGIA DO ESTADO DE SAO PAULO. Volume 5.
659 pages. 1946-1948.

North American taxonomic and medical entomologists can but illy afford to overlook the important contributions to their subject that are being made by their Brazilian coworkers. The "Arquivos de Zoologia" is an important medium for the publication of the work of these entomologists. The present volume contains ten articles, eight of which are of direct interest to entomologists. Included among these are Barretto's catalogue of the American *Flebotomus*, an apparently thorough work with references, citations, and a bibliography; the account of the second scientific expedition to Porto Cabral, on the Paraná, with much entomological material included, by Travassos and Carrera; and important works on the South American species of *Basilia* (Nycteribiidae), on the Mallophaga of Brazilian Psittacidae, and on the flea genus *Polygenis* by Guimarães, on the morphology, bionomics, and color phases of the butterfly *Pericopis picta* (Guérin) by Travassos, on the neotropical Opiliones by Soares and Soares, and on the neotropical Simuliidae by d'Andretta and d'Andretta. All articles in this volume are in Portuguese, sometimes with a brief English summary.—M. T. J.

THE NATURAL HISTORY OF MOSQUITOES, by MARSTON BATES. xv+379
　　　pages, 16 plates, 9 text figures. MacMillan Company, New York, 1949.
　　　Price, $5.00.

　　　The malariologist, the medical and general entomologist, and the student
of evolution will welcome this guide through a maze of information and published
research which is so extensive as to tax the abilities of the culicidologist to keep
abreast of it. The book is to an extent a compilation from the literature, though
the author's extensive experience in the field of malariology and mosquito biology
has made possible a critical evaluation of the material included, as well as the
addition of new materials. The versatility of the author, whose interests have
included, in addition to the present field, the Tephritidae, butterflies, human
biology, and the problem of evolution and the origin of species, and his ability
to write a clear and interesting style of English, have added to the readability
of the book and have enriched it with philosophical considerations.

　　　The work is not taxonomic or morphological, although four chapters deal
with taxonomic considerations and an appendix lists in systematic arrangement
all species mentioned in the text; neither does it deal with any of the aspects of
mosquito control. These, however, are not defects, as such material is readily
available from other sources. The main purpose of the book is to discuss mosquito
physiology and behavior, in respect both to those elements common to all mos-
quitoes and to those which show specific differences. He uses the term "natural
history" advisedly as distinct from "biology" which "covers all aspects of the
study of organisms and living processes without stressing one particular point
of view more than another, while natural history would levy contributions from
the various specialties only in so far as their material would directly help the
understanding of the living, functioning, whole organism." (p. 7.)

　　　The first part of the book deals with mosquito life histories, with a con-
sideration of the characteristics of behavior, physiology, and environmental
relationships of the various development stages. The environment, longevity,
distribution, sexual behavior, and food habits of the adult (pp. 13–81), the pro-
duction, deposition, structure, embryological development and hatching of the
egg (pp. 82–111), the environment, physiology, and behavior of the larva (pp.
112–178), and the role and behavior of the pupa (pp. 179–185), are discussed.

　　　The rest of the book considers mosquitoes in relation to other organisms, as
parasites, prey, hosts, and vectors, and in relation to viruses (pp. 186–238); the
species problem, particularly in relation to cryptic species in mosquitoes (pp.
239–256); the classification and distribution of mosquitoes (pp. 257–285); tech-
niques in mosquito study (pp. 286–303); and what the author calls "the strategy
of mosquito research," in which he emphasizes a main contention of the work,
namely, that the wealth of information obtained as a result of practical con-
siderations, may very well be utilized in practically untouched fields of pure
research (pp. 304–310).

　　　A list of 577 citations, through "certainly, less than a fifth of the papers that
have been published on mosquito behavior alone," is chosen to include references
that in their turn contain bibliographies of the separate subjects.—M. T. J.

PRINCIPLES OF INSECT PATHOLOGY, by EDWARD A. STEINHAUS. xi+757
　　　pages, 219 text figures. McGraw-Hill Book Company, Inc., 1949.
　　　Price $8.00.

　　　To the several facets of organized knowledge in entomology, now may be
added this remarkably effective, pioneer review of a fast growing but previously
scattered literature in the field of insect pathology. Though crude allusions
may be found to insect diseases even in certain ancient writings, few of us would
realize, before a more than casual examination of this fine work, that the author
had a literature of well over 5,000 titles upon which to draw for his text.

　　　As could be expected with regard to arthropods, the greatest advances in
basic information in insect pathology have been the results of man's economic
needs, but perhaps surprisingly, first in relation to the culture of his *insect friends*,
the silkworm and honeybee, even before attention was focused on diseases of his
insect enemies. The author lists, as an example, 62 abnormal conditions to which
the queen honeybee is subject. It also may come as a surprise to many that the

diseases of the silkworm were the first demonstrated microbial agents of animal maladies, though such readers may be aware that here Pasteur made some of his famous contributions both to science and to the improvement of a French industry. Contrary to what the title might imply, the volume discusses the beneficial as well as the deleterious microbial flora and fauna of insects and their allies. This book makes an excellent complementary volume to his previous work, "Insect Microbiology," with less overlapping than might be suspected from the titles.

Dr. Steinhaus brings to this really monumental work a most fortunate bacteriological background of training and experience, thus providing a stimulating presentation and viewpoint that will probably benefit entomologists even more than if such an inventory had been compiled by one strictly of his own profession. Though the author's stated "first objective" was to fill the need of students for a textbook of insect pathology, the volume reveals much more than the facies of a teaching manual, for it will be found to be an indispensible reference work to continued research, as well as to practical application in problems of "biological control" of insects in the field. One of the stimulating attributes of the volume is the "negative" one of pointing out "man's colossal ignorance of the subject" and the repeated warnings that the subject of "biological control" has passed the stages of either the early overoptimism or of the subsequent too reactionary pessimism, and should now advance by properly planned rationalization to take its earned place among other subsidiary entomological fields.

The author points out his intentional reference to only the most important literature, and it is remarkable that he kept his text within the 757 pages he did, for it is doubtful if ever again will it be possible to encompass as wide a discussion of such ancillary phases as abiotic and mechanical influences, parasitic infections, and biological control with its ecological implications and methodology plus comprehensive discussion of classes of microbial agents within the covers of one reasonably-sized volume. Certainly, correlative texts on the more intensively developed fields of vertebrate and plant pathology necessarily have become much more restricted in their respective coverages. The omission from any chapter of reference to Sweetman's previous book on "Biological Control of Insects" is noticeable in a work in which the present author's interest in biological control was a prominent motivating influence.

This volume is profusely and pertinently illustrated with 219 figures, well balanced with not only photomicrographs of pathological subjects, but also photographs of eminent contributors, of infected insect hosts, field equipment, and other gross subjects, and with charts and graphs, of which some 85 are originally presented in addition to many redrawings and adaptations from other authors. An especially valuable feature is the not inconsiderable amount of original data, though this will be more evident to those specializing in the field. Its value for rapid reference would have been enhanced had a summarical or host table been provided, at least for the microbial agents.

There is unquestionably a commendable advance in the systematization of the pathogenic agents of insect diseases through the author's familiarity with the International Rules of Bacteriology, but he also may be ahead of his time in adaption of Holmes' nomenclature of the viruses from the Bergey Manual (6th edition) since the binomial Latin system is still far from wide acceptance as applied to the animal viruses (for a supplemental and more intensive discussion of this phase of the subject, the reader may consult a later article by Dr. Steinhaus in Bacteriological Review for December, 1949).

But criticisms of this volume are trivial. The usual entomologist, often in an isolated location, might have wished that there had been an elaboration of the too brief and generalized reference to technics for diagnosis of insect diseases. How, for example, one unfamiliar with bacteriological techniques decides if a polyhedrosis is responsible for an insect's death as nearly as a slide smear would tell with suitable staining, if needed, would be vague to the nonspecialist though probably considered elementary by a bacteriologist. There are other perhaps unavoidable generalizations and unsupported statements without specific illustrations in some chapters, probably because much specific information is still quite elementary or because acquaintance with the pertinent facts is assumed from discussion elsewhere in the book. The still elementary state of our knowledge of this subject is repeatedly emphasized by his frequent need to resort to variations of the phrase "not enough is known . . ." We are indebted to Dr. Stein-

haus for this first inventory of the subject, and the volume is so overwhelmingly
a positive contribution to the field of entomology that all of us will continue to
expect more than ordinary things from the author in the future. He has undoubt-
edly provided a major acceleration to the field of insect pathology and it should
provide a stimulus to the neglected field of insect histology as well.
—CORNELIUS B. PHILIP.

AIR TRANSPORT AND INSECTS OF AGRICULTURAL IMPORTANCE,
    by W. A. L. DAVID. 11 pages. Commonwealth Institute of Entomology,
    London. Price 1 s. 6 d., post free.

Though no major agricultural pest has yet been known to have become estab-
lished in a new territory as a result of aircraft transportation, the danger of such a
thing happening is always present. This pamphlet attempts to review the most
significant information that has been accumulated concerning the actual and
possible transportation of insects of agricultural importance by aircraft and con-
cerning methods that should be used to prevent introduction of such insects into
new areas. A bibliography consisting of 42 titles is appended.—M. T. J.

CATALOG OF THE TERMITES (ISOPTERA) OF THE WORLD, by THOMAS
    E. SNYDER. Smithsonian Misc. Coll., vol. 112 (whole volume), pp. 1–490.
    1949. Price, $3.00.

This modern classification of termites was prepared by Dr. Snyder in
cooperation with Dr. A. E. Emerson, of the University of Chicago. Fossil forms,
as well as living ones, are included, though in a separate section of the catalog.
Synonymies and geographical and geological distribution, as well as the more
important references, are given. Ten new genera are proposed and described, and
several new species and new species names, in all cases based upon bibliographical
references only, are proposed. A species index and bibliography are given.

The progress of taxonomy is greatly hampered by the lack of adequate cata-
logs, and specialists in other orders might well be envious of their coworkers
who now have available so complete and useful a work as this. One confusing
feature which impresses me, at least on first consideration, is the failure to
differentiate either by style of type or position, the valid name of each species
and the bibliography references that follow. On the whole, however, this work
should prove easy to use.—M. T. J.

THE CARABIDAE OR GROUND BEETLES OF GEORGIA, by P. W. FATTIG.
    Emory Univ. Mus. Bull. 7. 62 pages. January 15, 1949.
THE LARVAEVORIDAE (TACHINIDAE) OR PARASITIC FLIES OF
    GEORGIA, by P. W. FATTIG. Emory Univ. Mus. Bull. 8. 40 pages.
    December 1, 1949.

These works represent the seventh and eighth of the author's serial contribu-
tions to the knowledge of insect forms of Georgia (see Ann. Ent. Soc. Amer.,
41: 563, 1948). The list of Carabidae includes 530 known Georgia species and an
additional hypothetical list of 121 species; a single species of Onophronidae is also
included. An interesting account of the bombarding beetles is given. The list
of Larvaevoridae includes 285 species.—M. T. J.

COLLECTING IN THE NATIONAL PARKS

Many collectors who are laying plans for the summer may not be aware of the regulations that govern collecting of animal life in the National Parks and Monuments. Some who are familiar with the procedures of past years are not aware of the change instituted by Field Order 768, June 17, 1949, of the National Park Service.

In a nutshell, the requirements now to be met by an applicant for a permit to collect animal life in the areas under the supervision of the National Park Service are these:

1. The collector must be a Federal employee.
2. The collecting must be for the benefit of the Park or for Science.
3. The specimens collected must be deposited in a museum or in the collections of scientific or educational institutions and made available to the public.

Items 2 and 3, above, have always been among the requirements. Unfortunately some of the collectors who were granted permission to collect in the National Parks under the former generous interpretation of the National Park Service Act of 1916 paid little attention to these requirements. They did either or both of two things that cannot be condoned: they over-collected rarities more or less confined to the reserved area or they did not properly deposit their collections but sold them.

The National Parks were created as refuges for *all* natural life and to preserve particular natural phenomena from destruction. Although the word "animal" is not defined in the original Act, it is interpreted in its scientific sense.

Mr. John E. Doerr, Chief Naturalist for the National Park Service, in a letter dated December 27, 1949, has expressed his opinion to me that the present ruling is not disadvantageous to the Park Service or to research. He states in reply to a specific question "Insects census work can be undertaken by any Federal employee who possesses the necessary permit which can be issued at the discretion of the superintendent. When a census is necessary and Federal employees cannot undertake the work, qualified specialists may be authorized to conduct the study by their appointment of collaborators without compensation." This is a clear statement that unless the National Park Service deems a census of some particular group of insects—or any other animal life—necessary there is little use for you to ask for appointment as a "collaborator without compensation." I am sure that a qualified specialist, working on a particular problem that involves areas under the supervision of the National Park Service, would have little difficulty getting full cooperation from the Service in being appointed "collaborator without compensation."

The appointment to such a position requires compliance with certain formalities. The specialist must furnish a record of qualifications, a promise of loyalty to the Government and a waiver of compensation.

All of this is being done to protect for the future relatively limited areas of natural terrain. If you do not have a really legitimate reason for being permitted to collect in a National Park or National Monument do not bother the Service for such a permit. The National Forest areas in the same general region will doubtlessly answer your purposes. Within the Park you will find generally at the headquarters of the Park Naturalist a collection of material that may answer your distributional problems. It often has done so for me.

If you do have a legitimate reason for collecting animal life in a National Park or Monument get busy about your permit early. Do not leave it until you arrive at the Park. Do this: first, write to the superintendent of the Park involved stating clearly your reason for wanting appointment as an unpaid collaborator; second, if your request is looked upon favorably by the superintendent he will send you copies of form 10-471; fill these in and return them promptly; third, do not do any collecting in a park area until you have a signed permit in your possession and only after you have discussed the "local ground rules" with a Park official.—F. MARTIN BROWN.

VULNERABLE AREAS ON THE SURFACE OF THE TARSUS AND PRETARSUS OF THE GRASSHOPPER (Acrididae, Orthoptera); WITH SPECIAL REFERENCE TO THE AROLIUM

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INTRODUCTION

Ten or twelve years ago, while studying the effects of dyes on the eggs of the grasshopper, *Melanoplus differentialis*, the present writer, in an idle moment, immersed a living adult of this species in one of the stains which happened to be on hand—just which one has been forgotten—and left it there for some time. Later, when the animal was removed and washed, the under surface of each arolium was found to be brightly colored; but no other part of the surface of the animal had stained. This seemed interesting and worth further study. Microscopic sections of the arolia were made and found to contain some unusual structures; but other work in progress seemed more pressing and nothing more was done with this at the time.

Recently an article by Kennedy, Ainsworth and Toms (1948) appeared in which experiments are described which deal with the relative effectiveness of several of the newer insecticides (the gamma isomer of benzene hexachloride, D.D.T. and 3,5-dinitro-ortho-cresol) when applied to various parts of the body of the African migratory locust, *Locusta migratoria migratorioides*. They state that "the toxic effect produced on the whole insect by applying DNOC solution directly to the legs was tentatively estimated as twice that produced by applications to the head and abdomen." The possibility that there might be a correlation between the findings of Kennedy, Ainsworth and Toms for *Locusta* and the earlier observations made by the writer on *Melanoplus* was obvious. More information on the permeability, histology, etc., of the arolia and associated structures was needed, however, before such a relationship could be established. The studies reported here were designed to supply some of that information.

EFFECTS OF DYES ON THE EXTERNAL SURFACE OF THE GRASSHOPPER

Most of the adult *Melanoplus differentialis* and all of the nymphs of this species used in these studies were taken from the writer's closely-inbred stock. A few adults, however, were caught outdoors. No difference in the reaction to dyes of the two kinds was found. A 0.1% solution of methylene blue was used in most experiments and gave very satisfactory results. Parallel tests with 0.1% solutions of neutral red, crystal violet and fast green were often run.

In a series of preliminary experiments lightly-anaesthetised adult grasshoppers were placed in small vials which were then filled to the top with stain and corked. An hour later each animal was removed, washed and examined under a binocular dissecting microscope. In almost every case the arolia were partly or wholly stained while other regions, with the occasional exception of some erratic coloring of the antennae, maxillary palps, labial palps and euplantulae, were entirely unaffected by the dye. During the course of such experiments the animals suffered from asphyxia and this method was soon abandoned for it was, obviously, desirable to keep the grasshoppers as normal as possible. Next the animals were placed in small, covered, glass dishes containing stain to a depth of 3 or 4 millimeters. Here the grasshopper was free to move and splash about and during the hour spent in the dish nearly every part of the body had some contact with the stain. The distal portions of the legs, however, were immersed nearly all of the time. Normal respiration was possible, for the spiracles were above the surface of the fluid. At the end of the experiment the animals were lively and exhibited no signs of injury. Petri dishes with a depth of 10 millimeters proved to be even more satisfactory as containers. This depth is sufficient to hold most adults of this species in place. The movements of the animal are greatly restricted and the feet cannot be lifted out of the stain but the spiracles remain above the surface of the fluid.

After an hour in the stain the grasshoppers were removed, washed and examined. As in the experiments where the animals were completely immersed, the under surface of each arolium was almost invariably found to be stained although the extent of the staining was not always the same. If little color was present it was usually located near the distal tip of the under surface of the arolium. When more color was present it extended proximally from this region. Frequently the entire arolium was deeply colored. Occasionally some colored areas were found on the euplantulae but these were much less regular in their distribution and very erratic in their appearance. It seemed probable that the staining of these parts was due to the fact that the cuticle had been damaged.

After the reaction of the adults to dyes had been studied with some thoroughness a series of experiments was begun with nymphs of different ages. The first results were puzzling. In some cases the nymphs reacted as did the adults and the arolia stained brightly; in others no staining occurred. The first clue to an understanding of this situation came when a large number of nymphs which had just hatched from the egg and were still soft and white were completely immersed in dye. When examined an hour later the arolia, and all other parts of the body

surface as well, were found to be as white as they were before the animals were placed in the stain. This suggested that in animals which had just molted—as do young grasshoppers immediately after leaving the egg— the new cuticle was in perfect condition and completely impervious to stains. It was only after the individual had jumped and crawled about for a time that the under surface of the arolia became worn and, consequently, permeable to dyes. Careful observation of the arolia of animals which were walking on the opposite side of a vertical glass plate supported this idea, for it is the extreme distal tip of the under surface of the arolium which is most often and most closely applied to the surface on which the animal is moving—and this is the region which stains most frequently.

To test this possibility further a number of nymphs (fourth, fifth and sixth instars) and adults were tested in shallow films of dye immediately after they had finished molting. Almost without exception the arolia of these newly-molted individuals retained their creamy-white appearance even after an hour in the stain. In the rare instances in which a small fleck of color was found this was associated with some visible injury to the cuticle.

EFFECTS OF ABRASION ON THE PERMEABILITY
OF THE AROLIA TO DYES

The next step was an investigation of the effects of abrasion on such individuals. Since it was scarcely practical to rub an abrasive on the under surface of each arolium, it was decided to study, instead, the effects of walking on an abrasive. A fine grade of sandpaper (2/0) was used. This when examined under the microscope was found to have particles with extremely sharp edges. A large glass vial (115 mm. long and 35 mm. in diameter) was lined with this sandpaper and . the animal placed inside. It was soon found that a grasshopper placed on such a surface would neither jump nor walk but stayed quietly in one spot.[1] It was not even necessary to cover the vial to keep the animal from escaping. When prodded or when the vial was rotated the animal could be made to crawl or jump. But it did so with great reluctance and often held one or more feet up and away from the sandpaper after having made such a movement. Some individuals proved to be quite skillful at resting or landing on the tips of their claws and holding the arolia flexed upwards away from the sandpaper. Others seemed to be less adept at doing this. Before being used in an experiment of this type each grasshopper was first tested by letting it stand for an hour in the dye solution. The arolia were then examined for colored spots and if any were found their position and size were recorded in sketches. The animal was then placed in the sandpaper-lined vial for thirty minutes and, at frequent intervals, was prodded or the vial was rotated to induce jumping. At the end of this period the grass-
. hopper was placed back in the dye again for an hour. In such animals

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[1]The importance of the shape of the particles became apparent when another type of sandpaper was tried. The animals walked about on this as if it were any ordinary surface. When examined under the microscope the particles on this sandpaper were found to be smoothly rounded.

the distal tip of the under surface of the arolia, in nearly all cases, showed a semicircular colored area. Obviously the outermost layers of the cuticle had been damaged by the sharp particles and the dye was now able to reach the inner, more permeable layers. We may conclude, then, that in animals which have recently molted the normal, uninjured cuticular surface is perfectly waterproofed, while in older animals it becomes worn and abraded so that stains can enter. Since the distal tip of the under surface of the arolium is, except for the tips of the claws, the part most frequently in contact with the surface on which the animal rests, walks or lands after a jump, it is not surprising that it should show the greatest signs of wear. Later it will be shown, in addition, that the microscopic structure of the cuticle of this region is such that it is more readily injured than it is on most other parts of the body surface.

EFFECTS OF XYLOL AND CARBON TETRACHLORIDE ON THE PERMEABILITY OF THE AROLIA TO DYES

Recent work of Wigglesworth (1945, 1946, 1947, 1948a, 1948b), Beament (1945, 1946a, 1946b, 1946c, 1947, 1948), Ludwig (1946), Slifer (1946, 1948) and others have stressed the importance of thin layers of wax in waterproofing the insect cuticle and egg coverings. Such layers not only control water loss and uptake but affect the resistance or susceptibility of the insect and its eggs to materials such as insecticides. The ease with which the cuticle of the under surface of the arolium can be damaged suggested that a delicate wax layer might be present here. To test this point the legs were removed from a young adult which had been lightly anaesthetised with CO_2 according to the method of Williams (1946). Anaesthetics such as ether and chloroform were avoided since they might have some effect on the orientation of the wax molecules in a thin layer and so alter the permeability of the structure under study (Wigglesworth, 1945). The cut surface at the coxal end of each leg was covered with "O.K. Liquid Solder"[2] to stop evaporation and to keep out any of the solutions which were used. This material dries very quickly and as soon as it had done so the prothoracic, mesothoracic and metathoracic legs from one side of the body were placed in a dish of xylol for fifteen minutes. The legs from the other side were, meanwhile, laid aside as controls. After removal from the xylol the three treated legs were allowed to dry on a piece of absorbent paper while being observed under the microscope. As soon as the xylol had disappeared from the surface the arolia, and soon afterwards the euplantulae, began to shrink very rapidly. An examination of the control legs at this point showed their arolia and euplantulae to be just as plump as they had been at the beginning of the experiment. A protective layer, soluble in xylol and probably of a waxy nature, had been removed from the xylol-treated legs and water was now evaporating through the arolia. Both the control and the treated legs were then placed in a solution of methylene blue. After 15 minutes they were all removed from the dye, washed, and

[2]This is a commercial product manufactured by the Tip-Top Products Company of Omaha, Nebraska.

examined.   The arolia of the control legs had retained their natural
color and showed no trace of stain but the arolia of the three xylol-
treated legs were a deep blue over their entire surface.   Moreover
they were now plump once more.   Evidently with the protective
layer dissolved away both the dye and the water passed in very quickly.
As these dark blue arolia dried they began to shrink rapidly again,
as did the euplantulae soon afterwards.

The experiment just described was repeated several times with
xylol and, later, with carbon tetrachloride as the solvent.   Besides
methylene blue, other dyes, such as a 0.1% solution of fast green and a
0.2% solution of acid fuchsin, were used.   In all cases the arolia of
the legs which had been treated with a wax solvent stained intensely
over their entire ventral surface while the arolia of the control legs
were completely impervious to the stain.

In addition to the deep coloration of the arolia of the xylol-treated
legs the general surface of the femora and tibiae was delicately tinged
with the stain which was employed.   This must mean that a small
amount of the dye is able to penetrate the cuticle of these parts after
exposure to a wax solvent.   It would seem, then, that the under surface
of the arolium is covered with a protective layer which can be easily
abraded or dissolved away while the rest of the surface of the leg is
covered with materials which are more difficult to remove or penetrate.
A cement layer of the type described by Wigglesworth (1945) for
Rhodnius may cover the wax in these regions.

STRUCTURE OF THE AROLIA AND EUPLANTULAE

The arolium of *Melanoplus differentialis* is large and extends to or
beyond the tips of the claws (figs. 7, 8, 9).   It is hard and pigmented
above and is soft, plump and ivory-white below.   When observed
in an animal clinging to the opposite side of a vertical glass plate, its
under surface can be seen to change shape frequently as the grasshopper
shifts its position.   The extreme distal tip of the soft under portion
is applied most closely to the glass.   No trace of any secreted, adhesive
material has been seen on that part of the glass from which the animal
has just lifted its foot.   All observations made so far suggest that the
ability of the arolium to stick to a surface is due to the close contact
made between this smooth, pliant structure and the surface on which
it is placed.   The arolium behaves like a small, rubber suction pad.
No characteristic differences have been noted, so far, between the
arolia of the two sexes or between those of the prothoracic, mesothoracic
and metathoracic legs.

The microscopic structure of the arolia and associated parts was
studied both in nymphs and adults and in animals which had just molted
as well as those which were about to molt and in still others killed at
known intervals after molting.   The feet were removed at the tibio-
tarsal joint from the living animal and dropped into the fixative where
the large claws which cause difficulty in sectioning were cut off.   Carnoy-
Lebrun's and Bouin's solutions were used as fixatives and the sections
were stained with Heidenhain's iron-hematoxylin, Mallory's triple
connective tissue stain or with Giemsa.

The structure of the arolium of *Melanoplus differentialis* is very peculiar (figs. 12, 14, 16, 17). It is hollow and filled with blood and is traversed by nerves and many tracheae. The cuticular wall of the upper surface is rigid and of moderate thickness (approximately 30μ). It is underlaid by an epidermis which is similar to that found in many other parts of the body wall. The ventral surface, on the other hand, shows a number of unusual features. The cuticle is extremely thick (approximately 200μ) and consists of several layers (figs. 12, 14). The innermost layer is made up of a mass of fibers which are very closely packed below but which are fewer in number and more widely spaced in the vicinity of the epidermal cells. Extending through the denser part of this layer and then below it in such a way as to form another thick layer are numerous rods which extend parallel to one another, and some distance apart, out towards the surface. Under an oil immersion lens extremely delicate filaments, resembling strings of minute beads, can be seen which connect each of these rods to its neighbors. These, it appears, permit the rods to move with some freedom, and, at the same time, prevent tangling of adjacent rods. Although it is not possible to decide the point with sectioned material it is almost certain that in life the rods are surrounded by fluid of some sort. As they approach the surface each rod breaks up, brush-like, into a very large number of excessively fine fibers. These form a distinct layer which becomes denser near the surface. Outside this a very delicate epicuticle can be seen. The waxy material, which can be removed with xylol, is located, presumably, on the outer surface of this layer. In adults killed and fixed immediately after they have molted for the last time the thick layer of elongate rods is present but the inner layers of fibers have not yet been formed. Wigglesworth (1948) states that in insects the endocuticle is produced after molting has taken place. If the time of formation, then, be used as a criterion the inner fibrous layers may be considered the endocuticle and the several layers of rods outside it the exocuticle. At the distal tip the cuticle is provided with a semicircular band of small tubercles (figs. 12, 13). It is in this region that the delicate epicuticle of the under surface changes to the more nearly typical epicuticle of the upper surface. As was pointed out above, the ventral surface of the arolium of a living grasshopper which is clinging to the opposite side of a vertical glass plate changes its shape frequently. Evidence from sectioned material indicates that as the surface is compressed and the cuticle, in consequence, decreases in depth, the long rods in the exocuticle flatten down close to one another against the inner layer. When the pressure is released, the rods move apart and extend out more nearly at right angles to the surface.

The epidermis which underlies the cuticle of the ventral side is also of an extraordinary kind. It consists of large, well-developed cells which cover irregular, longitudinal ridges on the inner surface of the cuticle (figs. 12, 14, 16, 17). Delicate fibers from the cuticle extend into many, if not all, of these cells and end just below the nucleus (fig. 16). These are especially clear in sections stained with Mallory's connective tissue stain. At first it was thought that these cells might produce a sticky material which would assist the animal in adhering
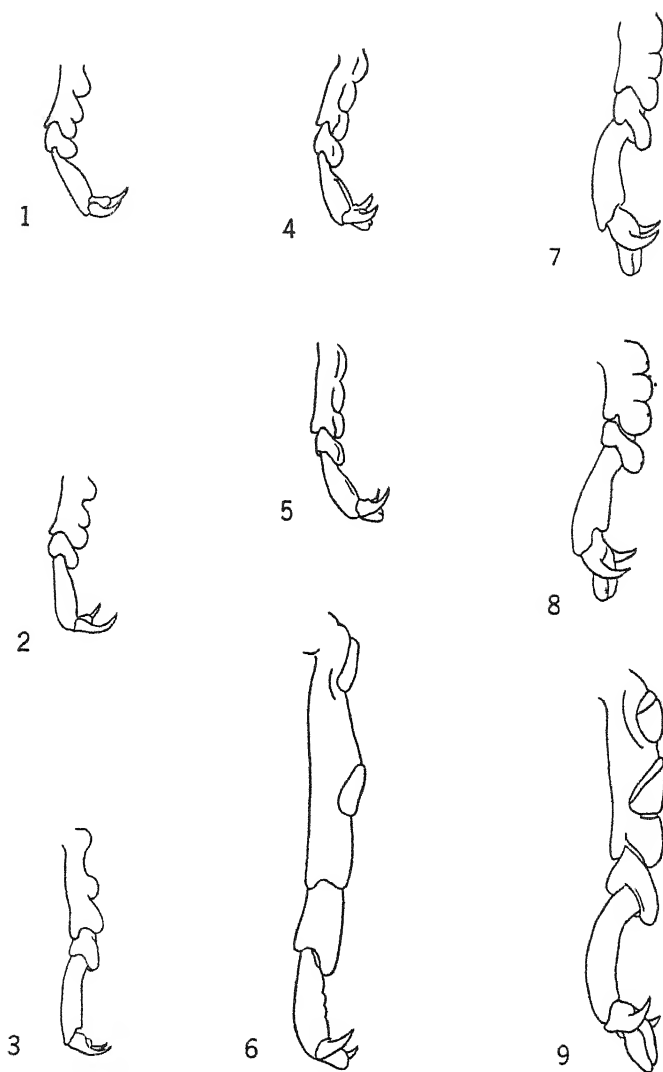
FIG. 1. Tarsus and pretarsus of prothoracic leg of adult *Trimerotropis maritima.* × 7. FIG. 2. Same as fig. 1 but mesothoracic leg. FIG. 3. Same as fig. 1 but metathoracic leg. FIG. 4. Tarsus and pretarsus of prothoracic leg of adult *Syrbula admirabilis.* × 7. FIG. 5. Same as fig. 4 but mesothoracic leg. FIG. 6. Same as fig. 4 but metathoracic leg. FIG. 7. Tarsus and pretarsus of prothoracic leg of adult *Melanoplus differentialis.* × 7. Fig. 8. Same as fig. 7 but mesothoracic leg. FIG. 9. Same as fig. 7 but metathoracic leg.

to a smooth surface; but the most careful examination has produced
no evidence, so far, of any ducts which might carry such a secretion
to the surface.[3]   It seems probably that their primary function is the
secretion of this complex cuticle.   They are responsible, also, for its
repair after it has been injured (see below).   Another likely function
of these cells (but one for which we have no definite proof as yet) is
the secretion of the fluid which permeates the cuticle.

The ventral surface of the arolium is provided with a number of
large sense organs (fig. 13) which probably have a tactile function.
In none of the experiments described here was any evidence secured
which would suggest that they serve as sites for the entry of materials
which are applied to the outer surface of the cuticle.

On the proximal portion of each tarsus and on its underside lie
the four euplantulae.   Each is composed of two lobes which lie side by
side.   The euplantulae of the prothoracic and mesothoracic legs as
well as the two distal euplantulae of the metathoracic legs are all much
alike in size, shape and texture.   The two euplantulae on the meta-
thoracic legs which are nearest the tibio-tarsal joint, however, are larger
and softer than are the others.   In color and general appearance the
euplantulae closely resemble the arolia but, as was noted above, are
covered with a more efficient protective layer, for when the xylol-treated
leg of a recently-molted individual is placed in a dye the euplantulae
do not stain.   Observations on living *Melanoplus differentialis* nymphs
and adults show that the euplantulae are often in contact with the surface
on which the animal is resting or moving, but somewhat less frequently
than are the arolia.   One would expect, then, that the euplantulae,
both because of the manner in which they are used and their more
resistant epicuticle, would be less liable to injury than are the arolia.
This is the case; but they do not escape entirely for older animals
often show darkened scars on the euplantulae and when tested with
dyes stain in these areas.

When microscopic sections of the euplantulae are examined the
epidermis and cuticle of the ventral surface are found to exhibit, in a
less extreme form, some of the features described for the arolia.   The
epidermal layer is arranged along irregular, longitudinal ridges on the
inner surface of the cuticle; but it does not show such extensive develop-
ment as does that of the arolia.   The cuticle consists of several layers
of fibers; but the layers are thinner and the details much less striking
than they are in the arolia.   The outermost cuticular layer of all of
the prothoracic and mesothoracic euplantulae and of the two distal
metathoracic euplantulae is relatively thick and amber-colored.   In
contrast with this the epicuticle of the underside of the two proximal
metathoracic euplantulae is thin and delicate and more closely resembles
that of the arolia.

Sense organs of the type found on the under surface of the arolia
are present on all of the euplantulae, except the two proximal ones
of the metathoracic leg.   In addition, other structures, which appear

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[3]Jannone (1939), who studied sections of the arolia of *Dociostaurus maroccanus*
concluded that the cells were not glandular.

FIG. 10. Longitudinal section through arolium of adult female of *Trimerotropis maritima*. Dorsal surface towards top of page; distal tip to right. × 82.
FIG. 11. Longitudinal section through arolium of adult female of *Syrbula admirabilis*. Dorsal surface towards top of page; distal tip to right. × 82.
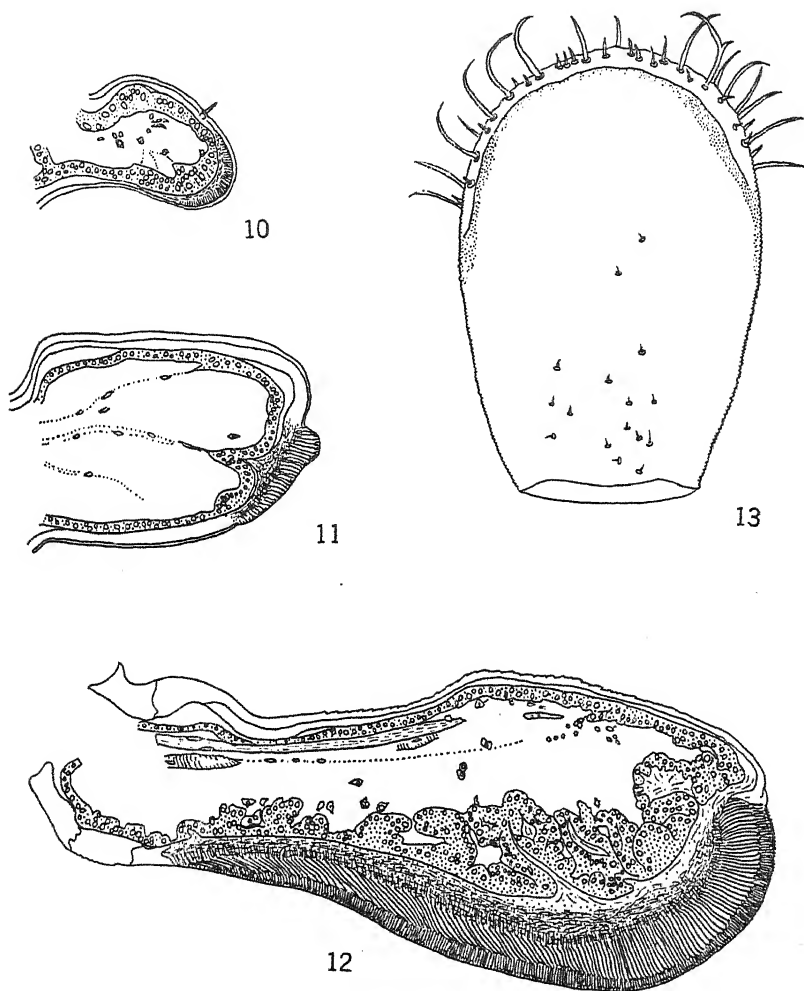FIG. 12. Longitudinal section through arolium of adult male *Melanoplus differentialis*. Dorsal surface towards top of page; distal tip to right. × 82.
FIG. 13. Ventral surface of whole mount of arolium of adult male *Melanoplus differentialis*. Distal tip towards top of page. Semicircular band of small tubercules just below distal tip represented by fine dots. × 45.

to be sense organs of the coeloconic type, are scattered over all of the euplantulae, including the proximal metathoracic. Detailed studies were not made of these; but each is provided with one or more large sense cells at its base and its outermost portion consists of an extremely delicate tubule which, after pursuing a somewhat winding course, opens on to the surface of the cuticle. Perhaps these are chemoreceptors. It would be interesting to know more about them.

REPAIR OF THE CUTICLE AFTER ABRASION

Since Wigglesworth (1945) has shown that damage to the wax layer of the epicuticle of *Rhodnius prolixus* nymphs can be repaired by a new secretion of wax from the epidermal cells which lie below the injured area it seemed probable that the abraded cuticle of *Melanoplus differentialis* might be repaired in the same way. To clarify this point a recently-molted adult male was tested in methylene blue. None of the arolia were affected by the stain. The animal was next placed in a vial lined with sandpaper for an hour and, after that, re-tested in methylene blue. All of the arolia now showed blue streaks and patches on their under surface. The animal was then placed in a large glass jar and provided with food. The smooth glass surface of the jar, it was hoped, would minimize the occurrence of any new abrasion. Four days later the animal was examined again and it was found that all color had disappeared from the arolia. The grasshopper was tested once more, for an hour, in methylene blue and the arolia were now found to be completely resistant to the stain. Presumably the damaged cuticle had been repaired by a new secretion of wax in the abraded areas. The experiment was repeated with another adult male and with neutral red as the stain in place of methylene blue. The results paralleled closely those of the first experiment and led to the same conclusion.

In the early experiments with dyes the adults used were secured either outdoors or from a laboratory colony for which no records had been kept concerning the age of the individuals after their last molt. The work just described indicates that young, newly-molted adults are able to repair damaged areas of the cuticle. It remained to be discovered whether this ability was retained by older grasshoppers. For this experiment animals were used which had become adult from five to six weeks earlier and which had been kept, meanwhile, in a wooden cage with sides of copper screen. The cage contained a dish of sand for the laying of eggs. These adults, consequently, had spent much of their time on rough surfaces. Ten individuals (five males and five females) were tested in methylene blue for one hour. In each of three of the animals one arolium was missing. Of the total number of arolia remaining 54 stained intensely, either wholly or in part, while the remaining 3 showed no trace of color. We may conclude, then, that as they age the animals either lose their ability to secrete a new wax layer or else that abrasions occur with such frequency that the repair process is unable to keep up with it. It would be interesting to know whether these older animals are more susceptible to the action of insecticides.
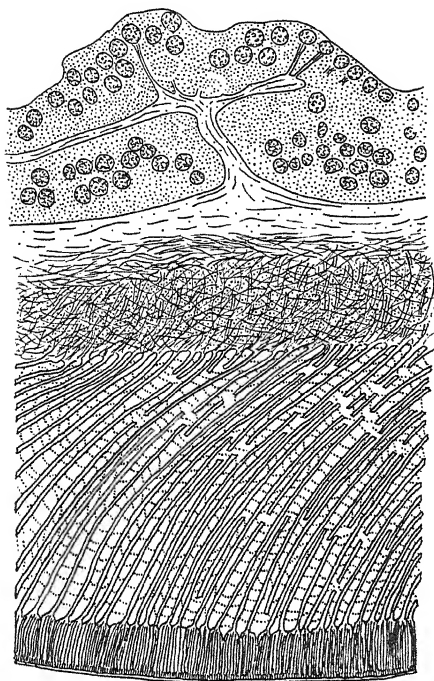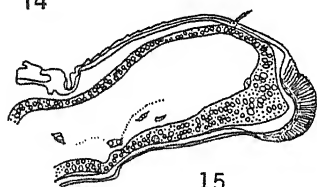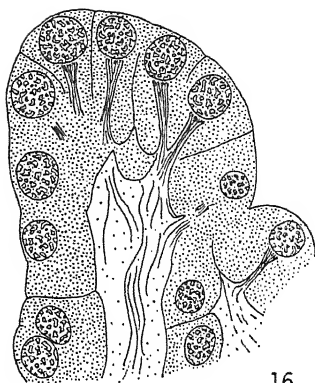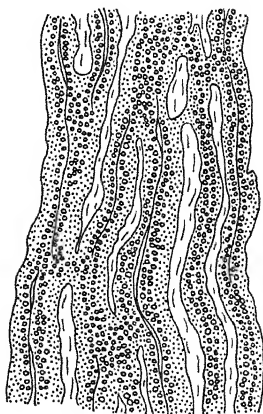
FIG. 14. Section through portion of ventral surface of arolium of an adult male *Melanoplus differentialis* killed 25 days after final molt. Epidermal cells above; below this the endocuticle in the inner part of which fibers are few and scattered and in the lower part of which fibers are numerous and densely packed. Below this lies the layer of elongate rods which are attached to one another by delicate, beaded filaments. These rods branch as they approach the surface. A very thin epicuticle covers the extreme tips of the branches of these rods. A delicate basement membrane (not drawn) is present at the inner surface of the epidermal layer. × 365. FIG. 15. Longitudinal section through arolium of fourth instar *Melanoplus differentialis*. Note small extent of the specialized epidermis and cuticle on the ventral surface. × 82. FIG. 16. Section through small portion of epidermal layer of arolium of an adult male *Melanoplus differentialis* killed 25 days after final molt. Extensions of the innermost endocuticular layer pass up into the cells and stop just below the nucleus. Cell boundaries not always distinct with stain employed. A basement membrane (not drawn) covers the inner surface of the epidermis. × 920. FIG. 17. Small portion of whole mount of ventral surface of arolium of adult male *Melanoplus differentialis* as seen from inside. Part shown includes only that visible in one focal plane. Branching and anastomosing masses of epidermal cells run lengthwise through the arolium. The areas between the cells are ridges of the endocuticle which extend upwards. × 120.

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A COMPARISON OF THE TARSI AND PRETARSI OF MEMBERS OF THE
SUBFAMILIES ACRIDINAE, OEDIPODINAE
AND CYRTACANTHACRIDINAE

During the summer of 1948 several dozen adult *Trimerotropis maritima* were collected by the writer on the sand dunes along the shore at Barnstable, Massachusetts. These belong to the subfamily Oedipodinae whereas *Melanoplus differentialis* is a member of another subfamily, the Cyrtacanthacridinae. *Trimerotropis maritima* is grayish-white in color and matches closely the white sand on which it is found. In *Trimerotropis* the arolia are reduced to tiny, hardened knobs which lie between the claws (figs. 1, 2, 3). The euplantulae and the claws are the structures which are most frequently in contact with the surface on which this grasshopper rests or moves. When these animals were tested by forcing them to stand in methylene blue, the arolia were found to be completely resistant to the dye. The euplantulae, on the other hand, showed many stained spots and since these were not distributed in any regular manner they presumably mark the sites of injuries.

After these observations had been made, two hundred and seventy-two species[4] of Acrididae in the author's collection were examined. Some of the specimens were preserved in fluid but most were pinned and dried. A determination of the degree of development of the arolia presents some difficulties for the size of the various species of grasshoppers themselves ranges from very small to very large and the arolia differ accordingly. It was decided, finally, to compare the length of the arolium with the length of the claws. A species, then, was recorded as having arolia one-quarter the length of the claws, one-third the length of the claws, etc. Since the claws are curved, their "length" was considered to be the maximum distance through which they extended in the curved condition. With no exceptions all the Oedipodinae examined had small arolia; frequently they were reduced to very tiny knobs. With a few exceptions the Cyrtacanthacridinae had large, conspicuous arolia. These, in the dried specimens, were usually badly shrunken on the under side but since the cuticle on the upper surface is quite rigid, no difficulty was encountered in determining their original size. The Acridinae, for the most part, had arolia which were intermediate between those of the other two subfamilies. The results of this study are summarized in Table I.

Next sections were made of the arolia of *Trimerotropis maritima* and of *Syrbula admirabilis* since fixed material of both these species happened to be available. *Trimerotropis* was taken as a representative of the Oedipodinae and *Syrbula* as a representative of the Acridinae. A longitudinal section through the arolium of *Trimerotropis* is shown in fig. 10. The normal cuticle, with its well-developed epicuticle, which is present on the dorsal surface of the arolium is only slightly modified on the under surface. The epidermal cells on the under surface are very little larger than are those on the upper. The differences between this type of arolium and that of *Melanoplus* are

[4]The species examined include most of those mentioned in three earlier articles (Slifer, 1939, 1940, 1943). A few of those listed there could not be used because the legs were either missing or in poor condition.

conspicuous. The arolium of *Syrbula* (figs. 4, 5, 6, 11) shows an intermediate type of development. The cuticle on its under surface is better developed than is that of *Trimerotropis* but not so extraordinary in structure as that of *Melanoplus differentialis*.[5] Jannone (1939) described the microscopic structure of the euplantulae and arolia of *Dociostaurus maroccanus*, also a member of the Acridinae. The results reported here agree well with his.

TABLE I

LENGTH OF THE AROLIUM AS COMPARED WITH THAT OF THE CLAWS

The figures given in the body of the table show the percentage of the species in each subfamily with a particular arolium/claw ratio. Fifty-two species of Oedipodinae, 71 species of Acridinae and 149 species of Cyrtacanthacridinae were examined.

Ratio of arolium length to claw length	Oedipodinae	Acridinae	Cyrtacanthacridinae
1/4	11.5	4.2	....
1/3	55.8	11.3	3.3
1/2	32.7	31.0	15.4
3/4	....	33.8	10.1
1/1	....	19.7	65.8
2/1	....	....	5.4

DISCUSSION

If, then, under natural, outdoor conditions, as the observations just described suggest, the under surfaces of the feet of the grasshopper are subjected to more frequent and severe abrasion than are other parts of the body surface it seems reasonable to assume that such areas would be among those through which insecticides would be most apt to penetrate. The experiments of Kennedy, Ainsworth and Toms (1948) are of especial interest in this connection. Since *Locusta migratoria migratorioides*, the species which they studied, is a member of the Oedipodinae, it is probable that the euplantulae rather than the arolia would be the important structures to be considered. These investigators applied the insecticide to the femora and tibiae of the grasshopper while it was fastened in such a way as to restrict movements. After 30 minutes it was freed and as the animal moved about, the insecticide was accidentally transferred to other parts of the body. At this point it would be possible for the chemical to reach the under surfaces of the euplantulae where, if the cuticle were not in perfect condition, it might pass through the body wall. Kennedy, Ainsworth and Toms' description of the behavior of individuals forced to walk on a glass plate on a film of oil which contained DNOC is of great interest in this connection.

[5]In his book, "Locusts and Grasshoppers" (p. 6, 1928), Uvarov states that the arolium "helps the insect in climbing, and it is, accordingly more strongly developed in those species that always live on plants (phytophils), while it is scarcely perceptible in the species living on the ground (geophils)."

According to them such an animal "soon began to raise one foot in the air, hold it there quivering slightly for several seconds, then put it down and raise another foot, and so on, as though the surface were hot to the touch." Throughout their paper these authors emphasize repeatedly the greater efficacy of a toxic material when applied to the legs rather than to some other part of the body.

Kennedy, Ainsworth and Toms used insecticides dissolved in an oil. As noted above, the facts available at present suggest that for the species with which they worked, *Locusta migratoria migratorioides* these materials would be most likely to penetrate through injured spots on the euplantulae. Other species, such as *Melanoplus differentialis*, which possess large, delicately-constructed arolia would have, in addition to abraded areas, a second avenue through which poisonous materials might reach the living tissues. The wax film on the under side of the arolium, since it is so readily dissolved in xylol and carbon tetrachloride, would almost certainly be disrupted by contact with an oil. With the waxy layer destroyed, a toxic material dissolved in the oil could then pass through the more permeable inner layers of the cuticle and so reach the epidermal cells. The ease with which this occurs would depend, no doubt, upon various physical properties of the materials involved—carrier oil, insecticide and cuticular components—as shown by Webb and Green (1945).

It would seem important, now, that the experiments of Kennedy, Ainsworth and Toms be extended and the insecticide be placed directly on the tarsi and pretarsi of animals which have molted recently and of others in which the under surface of the feet is known to be damaged. Perhaps the grasshoppers might be tested beforehand with harmless dyes, such as methylene blue, to see whether or not the cuticle is intact. Another interesting experiment would be a comparison of the effects of insecticides when applied to the arolia and euplantulae of species belonging to different subfamilies of the Acrididae. But in any work of this sort it would be essential that the condition of the cuticle—whether intact or injured—be known. It would also be advisable, if at all possible, to keep the animals under continuous restraint after the insecticide had been applied, so that the materials could not be transferred to some other part of the body.

Finally, it might be suggested that some of the techniques described here be tried out on other types of insects in order to determine whether vulnerable areas, on the feet or elsewhere, occur also in them.

CONCLUSIONS

1. The ventral surface of the arolia of newly-molted nymphs and adults of the grasshopper, *Melanoplus differentialis*, is impervious to water and is unaffected by aqueous solutions of dyes (methylene blue, neutral red, fast green, crystal violet).

2. In animals which have molted some time previously and in which the cuticle on the ventral surface of the feet has been worn or abraded, the arolia stain brightly, the dye entering through the damaged cuticle.

3. The arolia of newly-molted animals which are forced to walk or jump on sandpaper which is covered with sharp-edged particles

soon becomes abraded and when tested with dyes are found to stain readily.

4. For some time after molting the animals are able to repair damaged areas of the cuticle so that they again become impermeable to stains. In older animals this ability seems to be lost.

5. The waterproof layer on the under surface of the arolium of *Melanoplus differentialis* appears to consist of a very thin layer of wax or wax-like material, for it can be removed by treatment with xylol or carbon tetrachloride. After such treatment the ventral surface of the arolium stains even more brilliantly and uniformly than after abrasion, and water is lost or taken up through it with great rapidity.

6. The cuticle on the under surface of the arolium of *Melanoplus differentialis* is very thick and pliant and exhibits an unusual and complex microscopical structure.

7. No evidence was secured in the present studies which would suggest that the sense organs of the arolium serve as sites for the entry of dyes.

8. The arolia of *Trimerotropis maritima*, a member of the subfamily Oedipondinae, consist of small, hardened knobs which are very different from those of *Melanoplus differentialis*, which belongs to the subfamily Cyrtacanthacridinae. The arolia of *Syrbula admirabilis*, a member of still a third subfamily, the Acridinae, show an intermediate degree of development.

9. An examination of 272 species of Acrididae has shown that the arolia of the Oedipodinae are relatively small, those of the majority of the Cyrtacanthacridinae large, and those of the Acridinae, for the most part, intermediate in size.

10. The euplantulae of older adult *Melanoplus differentialis* and *Trimerotropis maritima* usually show from one to many colored patches when tested in dyes. These are commonly located in areas where the cuticle is visibly damaged.

11. In *Melanoplus differentialis* the two euplantulae which are nearest the proximal end of the metathoracic tarsus are softer, more delicate, and more easily damaged than the two which are distal to them, and than any of those on the prothoracic and mesothoracic tarsi.

12. It is suggested that the arolia and the euplantulae of the Acrididae, particularly after they have been worn or injured, serve as areas through which insecticides may enter with relative ease.

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BIOLOGICA. Instituto de Biologia, Faculdad de Biologia y Ciencias Medicas de la Universidad de Chile, Casilla 2988, Santiago, Chile.

We have received seven facicles (I, Sept., 1944, 141 pages; II, July, 1945, 143 pages; III, Dec., 1945, 110 pages; IV, July, 1946, 95 pages; V, Dec., 1946, but published in 1948, 66 pages; and VI and VII (double number), July-Dec., 1947, but published in 1949, 227 pages) of this periodical. The paper, except that used for the smooth half-tone plates, is a good-grade pulp, and the printing and illustrations appear quite satisfactory. Illustrations are used freely. The periodical as a whole presents a good appearance. All articles published so far are in Spanish, and all leading articles have summaries in German, French, English, and usually Spanish. A wide range of biological and medical fields is covered.

The articles of especial interest to entomologists include four on Chagas' disease and its pathological aspects: "Contribución a la anatomía patológica de la enfermedad de Chagas experimental," by Dr. Orlando Badínez S., fasc. 3, pp. 3–20; "Algunos aspectos de la enfermedad de Chagas experimental, comunicacion preliminar," by Dr. Tulio Pizzi P., fasc. 3, pp. 21–59, 64 figs.; "Observaciones histopatológicas de *Octodon degus* naturalmente infestados con *Trypanosoma cruzi*," by Carlos Whiting d'Andurain, fasc. 3, pp. 93–106, 12 figs.; and "Penicilina en medios de cultivo para *Trypanosoma cruzi*," by Dr. Tulio Pizzi, fasc. 3, pp. 107–109; and two on *Anopheles* and malaria: "Sobre el *Anopheles* (*Nyssorhynchus*) *pictipennis* Philippi, 1865," by J. Lane and A. Neghme, fasc. 4, pp. 83–93; and "Disminución invernal del anofelismo en Tarapacá," by Juan Noé and Prof. Guillermo Mann F., fasc. 5, pp. 3–14.

The double number comprising fascicles VI and VII is devoted to an account of the life and work of the eminent Chilean biologist and late director of the Instituto de Biologia, Dr. Juan Noé C. (1877–1947).—M. T. J.

[Word has been received from Dr. Amador Neghme, Chief of the Department of Parasitology, that the School of Medicine and the Department of Parasitology of the University of Chile, together with the library, scientific equipment, and collections, were completely destroyed by fire last year. Any help from North American coworkers will undoubtedly be greatly appreciated.]

A REVISION OF THE NORTH AMERICAN ANTS OF THE GENUS MYRMICA LATREILLE WITH A SYNOPSIS OF THE PALEARCTIC SPECIES. III.

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The preceding parts with this title were published in the Annals of the Entomological Society of America, September, 1947 (40:437-474, 3 text figs.) and June, 1948 (41:267-308, 7 pl.). They treated the genus as a whole (keys, distribution, affinities, etc.) and 20 species comprising 104 described forms. The present part deals with the North American *brevinodis* and its subspecies, which are among the commonest ants of this area, and 12 additional species of the Holarctic Region comprising 42 forms. A projected fourth part will summarize the data and contain addenda and an index.

THE HOLARCTIC SPECIES OF MYRMICA LATREILLE
(Continued)

Myrmica brevinodis Emery

M. rubra brevinodis Emery, 1894, Zool. Jahrb. Abth. f. Syst., 8: 312-313, ⍦.
M. rubra brevinodis Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 73-74; ⍦ ♀ ♂; Mann, 1911, Psyche, 18: 102.
M. brevinodis Wheeler, 1917, Proc. Amer. Acad. Arts Sc., 52: 502.
M. rubra brevinodis var. *canadensis* Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 76-77; Wheeler, 1910, "Ants," p. 566.
M. rubra brevinodis var. *subalpina* Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 77-78; Wheeler, 1910, "Ants," p. 566.
M. brevinodis var. *subalpina* Wheeler, 1917, Proc. Amer. Acad. Arts Sc., 52: 503.
M. brevinodis var. *alaskensis* Wheeler, 1917, Proc. Amer. Acad. Arts Sc., 52: 503; Wheeler, 1917, Bull. Mus. Comp. Zool., 61: 16.

The following descriptions have been drawn from a worker cotype from Salt Lake, Utah and from all castes of a single colony, taken by Dr. W. M. Wheeler, from Cheyenne Springs, south of Colorado Springs, Colorado.

Worker (cotype):—Length 5.0 mm.
Antennal scape extending to the occipital margin; basal fourth inwardly and evenly bent at an obtuse angle, gradually enlarging distally to about half the basal diameter. Mesoepinotal notch of thorax, when viewed in profile, shallow and broadly obtuse. Epinotal spines, seen from the side, shorter than the epinotal declivity, backwardly and only a trifle upwardly directed, somewhat curved downward at the tips; seen from above as long as the distance between them, subparallel. Petiole short, nearly as high as long, the mid-ventral tooth projecting anteriorly as far as the epinotal laminae; anterior face slightly concave, meeting the gently rounded dorsal surface at nearly a right angle, posterior declivity slightly concave. Postpetiole,

in profile, higher than long, from above transversely elliptical, being slightly broader than long. Gaster ovate. Legs of moderate length, first tarsal joint of mesothoracic leg slightly shorter than the four following joints.

Surface of body moderately but extensively sculptured. Median dorsal surface of head longitudinally and shallowly rugose; sides of head longitudinally but more vermiculate-reticulate rugose; back of head longitudinally rugose, medially and laterally reticulate; frontal area clearly delimited, shining, minutely punctate, scarcely striate; clypeus with seven ridges of moderate height between the frontal carinae. Dorsal surface of thorax coarsely vermiculate on the pronotum, becoming more finely and longitudinally rugose posteriorly; sides moderately and longitudinally rugose. Pedicel coarsely vermiculate except on the sides of the petiole where only feebly sculptured. Gaster smooth, but for slight scattered punctures, and shining. Body, except on the gaster, moderately punctate on the petiole. Antennae and legs comparatively smooth and shining.

Hairs of body moderately long and abundant, slender, pointed except on the thorax where truncate; subappressed on the antennae and legs.

Color pale brownish-red; a brownish median blotch on the head, gaster with a broad, transverse, median, brown band, legs and antennal scapes the color of the body, funiculi infuscated.

Worker (Colorado specimens):—Length 4.5-5.3 mm.

Closely resembling the cotype. The epinotal spines in some specimens are longer and not directed downwards at the tips; the spines may also be more divergent. In some specimens the clypeus has eight to ten ridges between the frontal carinae; the frontal area may also be distinctly, though finely, striate. The hairs of the thorax in many specimens are distinctly pointed. The general color of the majority of specimens is distinctly darker, the head dark red-brown, the thorax paler, and the gaster dark brown; the antennal scapes are characteristically a yellow brown and frequently contrast with a darker head.

Female:—Length 6.2-6.7 mm.

Similar to the worker with the usual sexual differences and the following:

Antennal scapes at the base slightly compressed and a little spatulate; epinotal spines somewhat shorter and distinctly blunt.

Sculpture coarser, the frontal area clear only at the base, the dorsal surface of the head medially vermiculate, laterally and posteriorly reticulate; pronotum reticulate-vermiculate, mesonotum variously sculptured, having a small, clear, triangular antero-median area, posteriorly about three median rugae, and laterally vermiculate; remainder of thorax irregularly rugose, finely punctate between; pedicel coarsely reticulate, densely punctate between. Hairs of body somewhat shorter. Color dark brown, almost black on the mesonotum with a darker median and two parapsidal blotches dimly showing, gaster shining black.

Wings hyaline, tinged with pale brown on the anterior margins, veins brown.

Male:—Length 5–6 mm.

Antennal scapes cylindrical, slightly bent medially, as long as the two following joints together; antennal club four to five jointed; petiole, from the side, rounded trapezoidal, as high as long, with a distinct
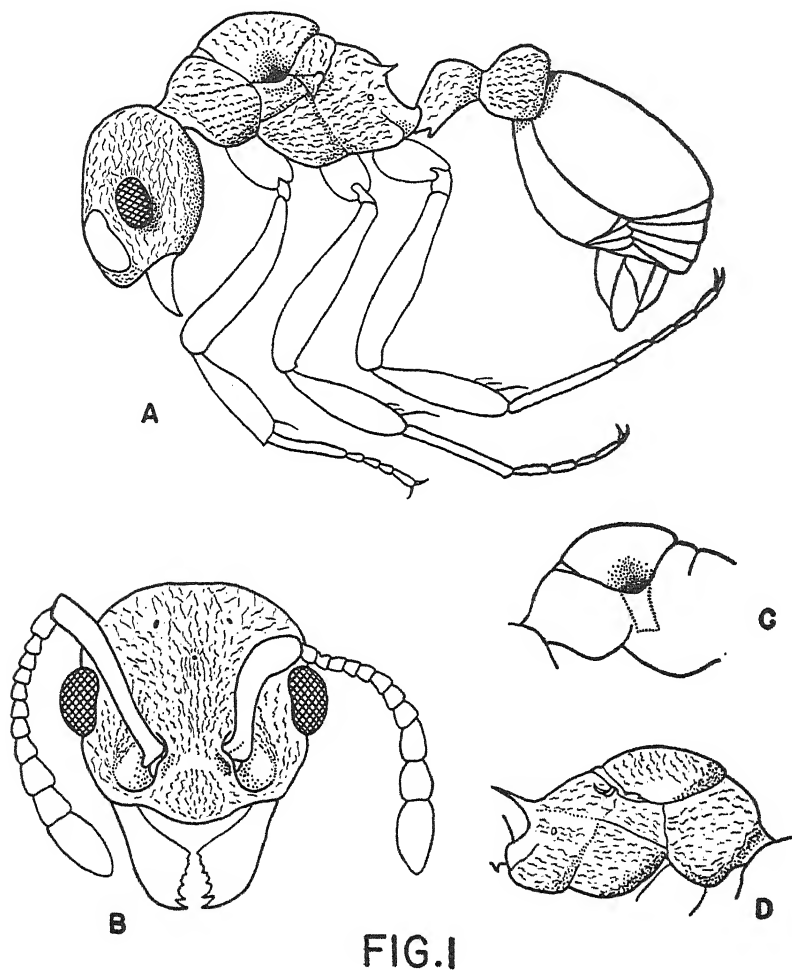
FIG.I

FIG. 1. Anomalous apterous *Myrmica schencki emeryana* individual whose asymmetry suggested to Professor P. W. Whiting gynandromorphism with mixed tissue. A. Lateral view from the left showing general external features of the female with male external genitalia. B. Frontal view of head. The antennae are twelve-segmented as in female and worker castes. The left antenna, however, has the scape short and elbowed, suggesting the male; ocelli, not present in the worker caste, are asymmetrical. C. Left side of thorax showing extent of deep hole by dotted lines. D. Right side of thorax showing worker-length epinotal spine and possible vestige of a wing.

ventral tooth which points as much downward as forward; sagittae of the genitalia with 28 to 33 serrations, volsellae as illustrated.

Surface of head finely striate, becoming reticulate laterally; thorax striate or rugose, with punctations between, and shining; pedicel densely punctate, lightly rugose dorsally; gaster shining, microscopically reticulate-punctate.

Hairs sparse except on head, short, fine and pale yellow.

Wings hyaline, faintly brownish along margins of veins, which are light brown.

Type Locality. UTAH: Salt Lake.

Other Localities. LABRADOR: Chateau Bay (no collector); Assizes Is. (H. H. Vogel). NEWFOUNDLAND: Bay of Islands, Spruce Brook (no collectors). NOVA SCOTIA: Cape Breton Island (G. B. Fairchild); Portaupinque, Penobsquis, Westchester Lake (C. A. Frost); Digby (J. Russell); Pleasantfield (W. H. Prest); Boisdale (no collector); Port Hawkesbury (W. H. Vogel). NEW BRUNSWICK: Grand Manan (no collector). QUEBEC: Hull, Chelsea (W. M. Wheeler); Magdalene Is. (H. H. Vogel). MAINE: S. Harpswell, Riverton (W. M. Wheeler); Kittery Point (U. S. N. M.); Ogunquit (H. S. Pratt); "Maine" (Pergande Coll.); Enfield, Presque Isle (M. W. Wing). NEW HAMPSHIRE: Mt. Washington summit (A. T. Slosson). MASSACHUSETTS: Boston region (N. A. Weber; W. M. Wheeler); Lawrence (S. Henshaw); New Boston, Berkshire County, 1,400 ft. (W. M. Wheeler). CONNECTICUT: Colebrook (H. L. Viereck, W. M. Wheeler). NEW YORK: Carmel, Richf. Springs (U. S. N. M.); Ashokan Survey, Bronxville (W. M. Wheeler); "New York" (Emery). PENNSYLVANIA: Bucks Co. (Bowman's Hill Dark), Centre Co. (The Rock), State Coll., Philadelphia, Ringtown, Bushkill Falls (W. L. Brown); Lehigh Gap (no collector); Towanda (N. A. Weber); Cameron Co. (Sinnemanhoning) (L. Stannard). NEW JERSEY: Ramsey (no collector). NORTH CAROLINA: Half-way Place, Summit of Black Mountain, North Fork, Swannanoa R. (W. Beutenmuller). TENNESSEE: Montvale Springs (C. H. Kennedy). ONTARIO: Lake Nipigon (L. Logier); Guelph (W. M. Wheeler); Lake Couchiching, Algon Park., Toronto, Macdiarmid, Sunbury (R. O. M. Z.); Moose Factory (A. Skinner); Manitoulin I. (C. H. Kennedy). OHIO: Adams Co. (C. H. Kennedy). ILLINOIS: "Illinois" (M. C. Tanquary); Champaign (T. H. Frison); Volo (R. E. Gregg). INDIANA: Lafayette (H. O. Deay). MICHIGAN: Marquette (M. Downing); Isle Royale (O. Gleason). WISCONSIN: Milwaukee (C. E. Brown); Superior (R. E. Gregg). IOWA: Ames (Pergande coll.). MINNESOTA: Duluth, Knife R., Saganaga L. (R. E. Gregg). MANITOBA: Pierson (N. A. Weber). SASKATCHEWAN: Gainsborough, Elmore (N. A. Weber). NORTH DAKOTA: Kelly, Grand Forks (N. A. Weber, E. & G. Wheeler); Bottineau, Drake, Towner, Minot, Rugby, Rock Lake, Belcourt, Turtle Mts., Butte, Bantry (N. A. Weber); Cass Co. (C. Schonberger); Niangara, Northwood (C. V. Johnson); Garrison (R. P. Uhlmann). SOUTH DAKOTA: "South Dakota" (Emery); Brownsville (W. S. Creighton); Hill City (W. S. Creighton, Pergande Coll.). ALBERTA: Banff (F. Silvestri, W. M. Wheeler); Edmonton, Bilby (G. Salt); Red Deer, Sylvan Lake ("J. D. T."); Jasper (C. Hewitt). WYOMING: Yellowstone Park (F. Silvestri, U. S. N. M.; A. C. Cole, Jr.). COLORADO: "Colorado"

(C. F. Baker, U. S. N. M., Pergande); Rocky Mts. National Park, Endovalley Camp, 8650 ft. (N. A. Weber); Winfield, Montrose (W. S. Creighton); Pingree Park (G. F. Knowlton); Florissant, Boulder, Meeker (T. D. A. Cockerell, W. M. Wheeler); Eldora, West Cliff, Salina (T. D. A. Cockerell); Steamboat Springs (Cockerell, Creighton); Colorado Springs (W. M. Wheeler); Ouray, Pueblo, Breckenridge (U. S. N. M.). IDAHO: Twin Falls, Stanley, Muldoon (A. C. Cole, Jr.); North Fork (W. S. Creighton). MONTANA: Helena (W. M. Mann). UTAH: Logan (G. E. Knowlton); Salt Lake Co., Heber, 5800 ft., Vernal, Ashley Co., 6000 and 7000 ft., So. Fork, Big Cottonwood, 7000 and 7400 ft., Deer Creek Res., 5700 ft., Soapstone Canyon, Vinta Mts., 9000 ft. (A. W. Grundmann); Utah Lake, Park City (U. S. N. M.); Bryce Canyon, La Sal Mts., (W. S. Creighton). ALASKA: Seward (F. H. Whitney, Frost); Fort Yukon, Pynaw Mts., Rampart, White Pass (J. A. Kusche); Fairbanks (N. A. Weber). BRITISH COLUMBIA: Emerald Lake, Carbonate, Lake Louise (W. M. Wheeler); Hector, Fields (J. C. Bradley); Golden (W. Wenman). WASHINGTON: Orcas Island (W. M. Mann.).

Males and females appear from about July 15 to September 19 (July 15, Connecticut; July 23-Aug. 9, Ontario; July 31, South Dakota; Sept. 5, North Dakota; Aug. 31-Sept. 1, Quebec; Aug. 28, Nova Scotia; Aug. 11-12, Sept. 19, Colorado; July 15, Saskatchewan; Aug. 10, 20, Alberta; Aug. 15, 16, British Columbia; Sept. 7, Alaska).

The variety *canadensis* has been synonymized with the typical *brevinodis* only after considerable search for characters which would consistently separate the two forms. One such character, which was believed to be consistent, was color. Specimens referred to the typical form by Dr. Wheeler (1907) from Colorado were pale red with the gaster a bright red-brown and agreed well with Emery's cotype from Utah. The variety *canadensis* was erected for the dark brown representatives from Canada and the Eastern United States. Among the thousands of myrmicas brought together in the collection since 1907, however, are pale red workers with the gaster bright red-brown from Maine, dark brown workers from Colorado and series from many regions with completely intermediate conditions. It was also found that epinotal spine length and depth of sculpture could not be relied upon, for the range within the same colony may be considerable.

Additional evidence for synonymizing the variety *canadensis* is presented by the males of the two forms. The male which Emery placed tentatively with the typical *brevinodis* cannot, as Dr. Wheeler (1907) stated, belong here because of the great length of the antennal scape and must belong to another form. The males, however, which were described as typical *brevinodis* by Dr. Wheeler have been examined and I find them to be *lobicornis fracticornis*, with the long antennal scapes equal to the five following segments; more conclusively, the genitalia, particularly the volsellae, prove it to be this *lobicornis* subspecies. These males were probably taken with the females which were typical *brevinodis*. Another instance of the mingling of sexes of different forms is listed under the subspecies *brevispinosa* where I took a *brevispinosa* female from a swarm containing *sabuleti* subsp. *americana* females as well as *Lasius niger* males and females. Similar cases are recorded by Donisthorpe and others from Europe.

The variety *alaskensis* has been synonymized after an examination of the types and specimens from Alaska later referred to it. I can not distinguish them consistently from many of the widespread typical *brevinodis* workers; a number of *brevinodis* workers have been examined with as few as eight rugae on the clypeus, though this is not the general condition. The discovery of the sexual forms may reinstate *alaskensis* as a distinct form.

The variety *subalpina* has also been synonymized after an examination of the types. The hairs on the bodies of most of the types have been found to be acute; some of the types have obtuse hairs in variable abundance intermixed with acute hairs, as if they had been broken off. While the wings of the type winged forms are hyaline throughout, there are transitions to this condition in typical *brevinodis* specimens and specimens from Ontario are before me with almost completely hyaline wings. The male gentalia are indistinguishable from the typical *brevinodis*.

Biology

This *Myrmica*, on the whole, prefers moist nesting sites and is one of the commonest bog-inhabiting ants. It is also found under bark or in rotted wood on the ground and under stones, but usually in moister situations than the other North American *Myrmica* forms are found. The brood occurs in a series of cavities in the top few inches of soil, among grass roots or in rotted wood.

A colony was taken from a slight depression in the dry, short grass prairie of northwestern North Dakota and taken to Cuba during the height of summer. Not only did the workers survive the change to a much moister and hotter climate but they reared other workers and several males before the colony was ended over a month later. The males emerged on July 18, several weeks earlier than they have been taken in North Dakota.

While the colonies of this form, as of *Myrmica* species in general, contain only a few hundred workers at the most, several colonies were discovered July 15, 1934 which far exceed any of which I have records. These colonies were found on either side of the Manitoba-Saskatchewan line just north of the United States-Canada boundary (Weber, 1941).

This region, having badly suffered from drouth for several consecutive years, was nearly denuded of vegetation and myrmicas could hardly thrive except in small areas. Such an area was the Canadian Pacific Railway right-of-way where, between the railway embankment and the surrounding prairie, a shallow ditch held a little moisture and supported more vegetation than the desert-like prairie.

On the north side, under scattered stones from the embankment, were found the polydomous colonies of *brevinodis*. In one case the nests extended along the ditch for fully 46 meters and laterally from one to three meters so that the area covered by the single colony was fully 100 square meters; there were probably over 100,000 adult ants. The nests were under scores of stones of variable size which were lying on the surface or embedded to a variable extent. Upon the roots of grasses which extended under the stones, or elsewhere where the ants had excavated chambers, were pastured both aphids and coccids. The

myrmicas carried these away when the roots were exposed and their excretions probably were the chief source of food of the ants.

Dr. Wheeler, in a series of papers (1901, 1903, 1907) has described the habits of an interesting inquiline ant, *Leptothorax emersoni* and its subspecies *glacialis*, which has established trophallactic relations with this ant.

Anomaly

An abnormal ant taken by myself in North Dakota August 26, 1934 belongs to this subspecies (Part II, 1948, p. 277, fig. 8). Head, thorax, appendages and petiole are those of a normal winged female. Seen from above, the postpetiole is fused asymmetrically to the gaster, whose long axis is directed at a distinct angle from the long axis of the body. Since the gaster is a dark brown and the pedicel red, the fused postpetiole may be readily traced. The dorsum of the postpetiole may also be traced by its rugosity to the left anterior region of the first gastric segment. The right side of the segment bears a red streak corresponding probably to the right side and ventrum of the postpetiole. From the suture between the first and second gastric segments, at the end of the red streak, exudes an amorphous mass. In side view the petiole seems directly attached to the gaster.

The insect was taken in the then nearly completely dried up bed of the Souris or Mouse River about 14 miles north of Towner, N. D. As I approached a small pool a cicindellid beetle flew away from the margin where it was attacking the ant. The myrmica was unharmed except for slightly torn metathoracic wings, which probably prevented it from attempting flight, and crawled with difficulty because of its abnormal abdomen.

A second anomaly is described under the subspecies *brevispinosa*.

Myrmica brevinodis subsp. sulcinodoides Emery

M. rubra brevinodis var. *sulcinodoides* Emery, 1894, Zool. Jahrb. Abth. f. Syst., 8: 313, ☿; Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 75–76, ♀; Wheeler, 1910, "Ants," p. 566.

M. brevinodis var. *sulcinodoides* Wheeler, 1917, Proc. Amer. Acad. Arts Sc., 52: 502; Wheeler, 1917, Bull. Mus. Comp. Zool. Harvard, 61: pp. 16.

M. rubra brevinodis var. *frigida* Forel, 1902, Trans. Ent. Soc. London, part 4: 699, ☿; Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 78; Wheeler, 1910, "Ants," p. 566; Santschi, 1909, Bull. Soc. Ent. Ital., 41: 5.

M. rubra brevinodis var. *whymperi* Forel, 1904, Ann. Soc. Ent. Belg., 48: 154, ☿; Wheeler, 1910, "Ants," p. 566.

M. brevinodis var. *whymperi* Forel, 1913, Bull. Soc. Vaud. Sc. Nat., 49: 215; Wheeler, 1917, Bull. Amer. Acad. Art. Sc., 52: 502.

This subspecies may be considered merely a darker, and more deeply sculptured form. Between this subspecies and the typical form exist specimens which may be with equal propriety referred to either. The male genitalia are practically indistinguishable.

The following descriptions are drawn from specimens of a single colony from Cheyenne Canyon, Colorado.

Worker:—Length 4.8–5.4 mm.

Antennal scapes smoothly but sharply bent at about 45° at the base, the base being dorso-ventrally distinctly compressed and somewhat spatulate, frontal lamina large, bent parallel to the head; epinotal

spines long, slender, and pointed, seen from above, divergent, longer than the distance between their bases.

Median dorsal surface of head, including clypeus and most of frontal area, strongly and longitudinally rugose, sides of head variably reticulate or longitudinally reticulate-rugose; back of head medially rugose, laterally reticulate-rugose; dorsal surface of thorax anteriorly strongly vermiculate, posteriorly becoming more rugose; sides of thorax longitudinally rugose, somewhat vermiculate on pronotum; pedicel strongly vermiculate, densely punctate between the vermiculations; gaster smooth and shining.

Hairs short, subappressed on head, erect on thorax, inclined and scanty on gaster.

Color of head and gaster dark brown, appendages and thorax brownish red.

Female (dealate):—Length 6.5–7.1 mm.

Resembling the worker with the usual sexual differences and the following:

Epinotal spines about as long as the distance between their bases, stout, blunt and widely diverging. Surface of the sides of the head strongly reticulate; surface of pronotum vermiculate anteriorly, rugose posteriorly; surface of mesonotum with a small, smooth and shining antero-median area from which radiate rugosities becoming regular and parallel immediately behind it (these are more numerous and regular than in the typical *brevinodis*); remainder of thorax chiefly rugose; pedicel vermiculate; gaster smooth and shining. Hairs short and scanty as in the worker. Color somewhat darker than in the worker, thorax in some too dark to show the antero-median and two parapsidal blackish blotches on the mesonotum.

Male:—Length 6.3–7.2 mm.

Antennal scape subcylindrical, slightly enlarged distally, a trifle bent, equal in length to the two following joints together; epinotal declivity dorsally with two low, obtuse gibbosities; antennal club four-jointed; petiole about as high as long, with a distinct subconic ventral tooth. Surface of head irregularly and shallowly reticulate, densely punctate between. Hairs yellowish, rather long and subappressed on the head, finer and scantier on the body. Color dark brown to black. Sagittae of genitalia with 32 to 36 serrations; volsellae as illustrated.

Type Localities. SOUTH DAKOTA, UTAH, MAINE.

Other Localities. ALASKA: Homer (A. Menner); Sitka (T. Kincaid).[1] NEWFOUNDLAND: Bay of Islands (L. P. Gratacap). MASSACHUSETTS: Essex County (King); Naushon Island (W. M. Wheeler). MAINE: "Maine" (Emery); Ogunquit (Pratt). INDIANA: Valparaiso (M. Talbot). MICHIGAN: Warrens Dunes (M. Talbot). WISCONSIN: Lake Geneva, Williams Bay (Ill. Nat. Hist. Surv). NORTH DAKOTA: Towner, Bantry (N. A. Weber). SOUTH DAKOTA: "South Dakota" (Emery); Hill City (Pergande Coll., N. A. Weber). WYOMING: Big Horn National

[1]Also Kodiak, all castes, Aug. 5 (N. A. Weber); the ants were markedly larger and much less concolorous than those of *brevinodis* taken 400 miles north at Fairbanks.

Forest (W. S. Creighton).   MONTANA: Bear Paw Mt. (Pergande Coll.);
Helena (W. M. Mann).   IDAHO: Galena (A. C. Cole, Jr.).   COLORADO:
Boulder, 5,347 feet, Ward (W. W. Robbins); Cheyenne Canyon, 5,990
feet, Ute Pass, Florissant 8,000–9,000 feet, Colorado Springs (W. M.
Wheeler); Westcliffe 7,849 feet (P. J. Schmitt); Winfield, Steamboat
Springs (W. S. Creighton); Rico, 10,000 feet and Hayden Peak 10,000
feet (E. J. Osler); Lost Lake, Eldora, 9,500 feet (D. M. Andrews);
Gregory Canyon, Boulder (L. F. Byars); Breckenridge, Ouray, Denver
(U. S. N. M.); Nederland, 9,600 feet (F. H. Carpenter).   NEW MEXICO:
Beulah, 8,000 feet, Rociada, Upper Pecos Valley, Top of Las Vegas
Range, 11,000 feet (T. D. A. Cockerell); N. E. Truchas Peak, 12,-13,000
feet (A. Springer).   UTAH: "Utah" (Emery); Park City, Salt Lake
(U. S. N. M.); Logan, Woodland (Knowlton); Cache Co. (Smith);
Mirror L., Uinta Mts., 10,000 feet (W. S. Creighton).   ARIZONA:
Kaibab National Forest (W. S. Creighton).   ALBERTA: Lake Louise
(W. M. Wheeler); Soda Lake (G. Salt); Jasper (C. G. Hewitt); Vermillon
Pass (E. Whymper).   BRITISH COLUMBIA: Ice River Valley (E.
Whymper); Hector, Carbonate and Spillimachen R., Selkirk Mts.,
(J. C. Bradley); Field, Emerald Lake, Yoho Pass (W. M. Wheeler);
Victoria (P. J. Darlington).   WASHINGTON: Orcas Island (W. M. Mann).
CALIFORNIA: Tallac, Lake Tahoe, 5,200 feet (W. M. Wheeler); Sisson
(F. Silvestri).

The winged forms appear Aug. 1 (Wyoming), Aug. 2 (New Mexico).

The varieties *whymperi* and *frigida* have been synonymized with
sulcinodoides after an examination of the original descriptions and of
many specimens from British Columbia, including two cotypes of
whymperi. The descriptions fit Emery's previously described subspecies
very well and the ants belong to the same *brevinodis-sulcinodoides*
complex. The *whymperi* cotypes have slender, acute, and strongly
diverging epinotal spines which are about 1½ times as long as the
distance between their bases. The dorsal surface of the pedicel is
strongly vermiculate.

Myrmica brevinodis subsp. kuschei Wheeler

Myrmica brevinodis var. *kuschei* Wheeler, 1917, Bull. Mus. Comp. Zool., 61: 17, ⚇ ♀.

Worker:—Length 3.7–4.5 mm.

Antennal scape evenly bent at the base and slightly compressed;
epinotal spines as short or shorter than the distance between their
bases, divergent, straight, directed backwards and only slightly upward.

Median dorsal surface of head rather finely rugose, about 8 more
coarse and more widely separated rugae on the clypeus, frontal area
shining, slightly punctate, sides of the head elongate-reticulate, in front
of the eyes longitudinally rugose. Dorsal surface of thorax vermiculate-
reticulate; lateral surfaces longitudinally rugose, somewhat vermiculate
on the prothorax. Pedicel vermiculate, mid-dorsal surface of the
postpetiole smooth and shining. Surface of head, thorax and pedicel
densely punctate at the base of the sculpturing. Thorax smooth and
shining.

Hairs of the body moderately short and obtuse or truncate, possibly
from having been broken off; hairs of the gaster sparse, except on the
sutures.

Color of head and gaster reddish brown, rest of body and appendages pale brownish red.

Female (dealate):—Length 5.8 mm.

Resembling the worker, with the usual sexual differences and the following:

Epinotal spines moderately diverging, straight and bluntly tipped, distinctly shorter than the distance between their bases. Pronotum coarsely reticulate, becoming finely rugose posteriorly; antero-median area of the mesonotum clear, posteriorly the median surface has several longitudinal rugae which are bordered on the side by irregular vermiculations; between the vermiculations are large and distinct pits or coarse punctures; remainder of thorax longitudinally rugose; dorsal surface of the petiole transversely rugose; surface of the postpetiole concentrically rugose, the rugae becoming transverse posteriorly; ventral surface of the pedicel densely, dorsal surface lightly, punctate; gaster smooth and shining.

Hairs as in the worker, short, sparse and truncate.

Color of body dark brown, the gaster distinctly paler than the head or thorax; appendages pale brownish red.

Described from the type female, a series of worker cotypes and a worker from the Pergande collection. As Dr. Wheeler (1917b, p. 21) pointed out, this specimen was included by Pergande in his *Myrmica scabrinodis* subsp. *lobicornis* var. *lobifrons*.

The sculpturing of the female is distinct from that of any of the other *brevinodis* forms although the workers closely resemble those of the typical *brevinodis*. Males have not yet been taken.

Type Locality. Alaska: Ketchikan (J. A. Kusche).

Other Locality. Alaska: Metlakahtla (T. Kincaid).

Myrmica brevinodis subsp. brevispinosa Wheeler

M. rubra brevinodis var. *brevispinosa* Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 74, ☿ ♀ ♂; Wheeler, 1910, "Ants," p. 566.

M. brevinodis var. *brevispinosa* Wheeler, 1917, Proc. Amer. Acad. Arts and Sc., 52: 502.

M. rubra brevinodis var. *decedens* Wheeler, 1907, Bull. Wisconsin Nat. Hist. Soc., 5: 75; Wheeler, 1910, "Ants," p. 566.

M. brevinodis var. *decedens* Wheeler, 1917, Proc. Amer. Acad. Arts and Sc., 52: 502.

The following descriptions are drawn from cotypes.

Worker:—Length 3.8–5 mm.

Antennal scapes in the form of a long drawn out sigmoid curve; slightly compressed dorso-ventrally at the base and with a distinct though shallow sulcus; the posterior margin of the base is furthermore drawn out as a slight keel. Mesoepinotal suture of thorax, in profile, averaging somewhat deeper than in the typical *brevinodis*. Epinotal spines extending backwards and, at a very slight angle, upward; short stout, about as long as the excision of the lamellae directly under them, or as the distance between their bases. Petiole, in profile, three-fourths as high as long; the anterior face flat or slightly concave, the dorsal faces gently convex, the two enclosing a rounded right angle; median ventral tooth small, rounded, and extending backwards as a slight rounded keel. Postpetiole, in profile, three-fourths as long as high, with evenly rounded dorsal, and irregularly convex ventral, surface.

Surface of dorsal area of head shallowly and longitudinally rugulose, becoming reticulate laterally and on the posterior margin, thickly punctate between; frontal area punctate, shining; clypeus rugose; antennal scapes punctate. Dorsal surface of thorax coarsely reticulate or vermiculate-rugose, becoming somewhat more regularly and longitudinally rugose, densely punctate between. Surface of pedicel comparatively smooth and with only faint reticulations, densely punctate between. Gaster smooth and shining.

Hairs moderately abundant, generally obtuse on the head and thorax, finer, shorter and more abundant on the gaster.

Color brownish red, gaster dark brown apically.

Female:—Length 5.3–6.3 mm.

General form of the worker with the usual differences and the following:

Surface of the pronotum reticulate, more coarsely on the dorsal surface, less on the sides, densely punctate between the reticulations; remainder of the thorax rugose.

Color of body and appendages brownish red; dorsal surface of mesonotum with two parapsidal dark brown blotches; gaster shining dark brown, light brown apically. Wings hyaline with the base clear; veins light brown.

Male:—Length 5.2–5.4 mm.

Antennal scape slightly bent medially, a little larger in diameter at the distal than at the proximal half, equal in length to three to four of the following segments together. Epinotum dorsally with a gibbosity on each side. Each sagitta of the genitalia with 24 to 27 serrations; volsellae as illustrated.

Head shallowly rugose-punctate; thorax anteriorly smooth or finely punctate anteriorly, somewhat shallowly rugose posteriorly; pedicel smooth or finely punctate; gaster smooth.

Color of head black, rest of body and appendages dark brown. Wings hyaline, faintly tinged with yellowish bassally; veins light brown.

Type Localities. COLORADO: Cheyenne Canyon, 8,500 feet and Colorado City, 6,064 feet (W. M. Wheeler); Canon City, 5,329 feet (P. J. Schmitt). NEW MEXICO: Las Vegas, 6,398 feet, Pecos, 6,366 feet (T. D. A. Cockerell).

Other Localities. COLORADO: Buena Vista, 7,900 feet, Colorado Springs, Denver, Cheyenne Canyon, Manitou, (W. M. Wheeler); Florissant, 8,500–9,000 feet (T. D. A. Cockerell, W. M. Wheeler); Wolf Creek (W. S. Creighton); Longmont, Fort Collins (E. S. G. Titus); Mountain House Lake, Fort Garland, 8,300 feet (no collector); 10 mi. N., Denver (N. A. Weber). UTAH: Price, Carbon Co. (P. Koller); Johnson Creek, Abajo Mts., 7,000 ft., San Juan Co. (A. W. Grundmann). NEW MEXICO: Taos (A. C. Cole, Jr.); Little Tesuque Canon, 9,200 feet, Santa Fe, (W. M. Wheeler); Pecos Mts., San Mejuel County (Mitchell). CALIFORNIA: Lake Tahoe (W. M. Wheeler). ILLINOIS: Volo (R. E. Gregg). MICHIGAN: Crystal Falls (A. C. Cole, Jr.). MINNESOTA: Oslo, Marshall Co. (N. A. Weber); Duluth, Holyoke (R. E. Gregg). NORTH DAKOTA: Mikkelson (J. E. Goldsberry); Amidon (E. & G. Wheeler); Stark Co. (R. P. Uhlmann); Hebron (E. Krauth); Devils Lake, N. Roosevelt State Pk., Towner, Bismark, Arvilla, Grafton,

Wing (N. A. Weber); University (L. Monda); Cass Co. (C. Schonberger). SOUTH DAKOTA: Rapid City (N. A. Weber). MONTANA: Belt (W. S. Creighton). WYOMING: Cheyenne, Evanston (N. A. Weber). IDAHO: North Fork (W. S. Creighton). ONTARIO: Nipigon, Ft. William (N. A. Weber); Manitoulin I. (C. H. Kennedy).

The winged forms appear July 19–Aug. 18 (Colorado); July 27–Aug. 10 (New Mexico); Aug. 21 (Idaho); Aug. 28 (Montana); Sept. 5 (Utah); and Sept. 10–28 (North Dakota).

The combination of the compressed and grooved basal portion of the antennal scape with the short epinotal spines easily distinguish the worker of this subspecies from the other *brevinodis* forms; the males are easily distinguished by the length of their scape.

The variety *decedens* Wheeler has been synonomized with *brevispinosa* after the examination of the type specimens of the two and the finding of a considerable number of completely intermediate forms. The epinotal spines of the two from actual measurement average practically the same, there being an appreciable deviation on both sides of the average in both series. The size of the *decedens* workers averages a trifle smaller but well within the normal range, even within a single colony, of a *Myrmica* form. The surface of the thorax is similar.

As is to be expected, the structure of this subspecies shows considerable variation. The dorsal surface of the thorax of the worker is generally vermiculate-rugose but specimens from the same colony may be, on the one hand, distinctly reticulate, or, on the other hand, longitudinally rugose. Within the same colony may be considerable range in size of the epinotal spines. Indeed, in a single Florissant, Colorado, specimen the spine on one side of the epinotum was typically short as in *brevispinosa*, on the other side, however, it was equally typical *brevinodis*! The spines were entirely normal in appearance.

The color of *brevispinosa*, on the whole, is lighter than that of the other forms. The color of the females varies little; the darkest female seen was one with the gaster entirely dark brown and the general tone darker, which I took at Fort William, Ontario. The darkest workers examined were taken at Nipigon, Ontario, in the midst of the "bush" or extensive spruce woods.

Biology

Dr. Wheeler notes that in Colorado the colonies are "rather small, nesting under stones in grassy places on the banks of streams." In North Dakota I have found the small colonies in similar situations and also nesting in sand on the prairie. Other ants occupying the same ecological formation in the sandhills south of Towner, North Dakota, include *Solenopsis molesta* Say, *Lasius niger* var. *americana* Em., and *Formica (F.) bradleyi* Wheeler. Near the shore of Round Lake, McHenry County, North Dakota, the workers of this variety were observed tending the aphids, *Anuraphis* sp. (det. P. W. Mason) on the taproots of the dandelion (*Taraxacum officinale*). On nearby willow trees workers of *Formica rufa obscuripes* Forel were tending the aphids, *Chaitophorus populifoliae* (Oest.) (det. P. W. Mason) and it is probable that the myrmicas would visit these aphids also when the more aggressive

formicas would be absent. At Towner upon a September 10th, I captured a female of this variety in a swarm with *M. sabuleti* ssp. *americana* females and *Lasius niger* males and females. The ants were part of a steady stream flying just above the level of the tree tops in the shallow Mouse River Valley. The day was calm so winds could not account for this mixed swarm.

Anomaly

A curious anomaly from Belt, Montana, taken by Dr. W. S. Creighton belongs to this subspecies (Part II, 1948, p. 277, fig. 7). It was taken in company with entirely normal workers. In this specimen the post-petiole is absent and the petiole is fused to the epinotum. In a dorsal view the line of fusion is transverse and clearly indicated; the epinotum is without trace of spines; the fused petiole is slightly broader than the adjacent part of the thorax and has evenly convex sides; the gaster is joined to the petiole by its normal slight peduncle; the sculpturing of the petiole is very irregularly reticulate-rugose, smoother and not longitudinal as on the epinotum; the pilosity is that of the normal petiole. In lateral view about one-half of the epinotum is seen to be missing, all of the petiolar peduncle and the entire postpetiole; the lateral line of fusion is not so distinct but it appears that the fusion is not entirely vertical, the petiole having been carried into the thorax a little; oddly enough the ventral margin is much like that of the post-petiole although the remainder is clearly that of the petiole; as on the dorsal surface, the sides are more feebly and indistinctly sculptured than on the thorax. Even allowing for the fusion of parts of the worker, it is a little undersized.

At least five abnormalities of the same nature are recorded in the ant literature. As mentioned in Part II, 1948, p. 292, the *Myrmica* female lacking the entire pedicel described and figured by Creighton (1920), belongs to *M. sabuleti* subspecies *americana*.

Donisthorpe, in 1922, records a similar female of *Leptothorax acervorum* F. and Forel a worker of the same species with the pedicel firmly fused to the metathorax. Karawajew (1927) described a worker of *Megaponera foetens* F. without a petiole. In 1946 I figured and described a worker of *Oecophylla longinoda* (Latr.) with the petiole telescoped into the epinotum (Weber, 1946). This *brevispinosa* worker and the *brevinodis* female above described add two records to the five listed which would seem to indicate that this type of monstrosity, in which there is a telescoping of the pedicel with the thorax or gaster, is commoner than any other abnormality in ants, aside from intersexes or gynandromorphs.

Myrmica brevinodis Emery subsp. discontinua Weber

M. brevinodis Emery ssp. *discontinua* Weber, 1939, Lloydia, 2: 150, ⚨.

Worker:—Length 3.3–4.2 mm.

General habitus as in *brevispinosa*, with the following differences: Antennal scape at the base more compressed, with a distinct keel on the proximal part at medial angle of the bend, (when the scape is extended posteriorly towards the mid-occiput), which may be prolonged distally and bifurcated, following the lateral and medial margins for

anteriorly, appearing as a small very acute extension of the bend. Epinotal spines long.   Otherwise nearly as in the preceding.

Female (after Nylander):—Length 2½ lin.

Similar to the worker, but much darker.   Head fuscous, ferrugineo-testaceous between the genae, on the mandibles and antennae, frontal area scarcely apparent.   Scapes bent at the base, dorsally with a suberect angle, arcuate beneath, no distinct lobe.   Epinotal spines as in the preceding species, but nodes of the pedicel roughly sulcate-rugose.   Wings whitish hyaline, about 2½ lin. long; between the stigma and the base faintly pallid-cinereous.

Male (after Nylander):—Length 2½ lin.

Similar to the male of *M. laevinodis*, antennae, in truth, as long as the funiculus in the same species, scape one-fifth as long as the rest of the antennae, legs with long yellow pilosity.   Mandibles apically pale and sordid.   Antennae obscurely rufous, with longer and more slender pilosity than in the female and worker; scape subcylindrical, as long as the three following segments, of the thickness of the last segment, moreover; first funicular segment suborbiculate, broader than any of the seven following joints, which have long vertical pilosity; ninth, tenth and eleventh suborbiculate, broader; last segment subconic, nearly as long as the tenth and eleventh taken together, but in the same way broad at the base.   Wings less whitish than in the female.   Legs with long pilosity on all sides, cinereous hairs on the tarsi almost longer. Anus sordid.

For recent discussions of this species see the bibliography given above and also Emery (1908, pp. 174–177).   It remains for European myrmecologists to find Nylander's types or to agree upon a typical form.

This species is widely distributed over Europe and North and Central Asia.

Myrmica scabrinodis var. ahngeri Karawajew

M. scabrinodis var. *ahngeri* Karawajew, 1926, Mem. Acad. Sc. Ukraine, 4: 66, 67, fig. 3; 2 ♀.

Worker (after Karawajew):—Length 4.5 mm.

Head hardly longer than wide, hardly broader posteriorly than anteriorly and the anterior margin of the clypeus more projecting than in the typical form.   The frons broad, occupying about one-third of the width of the head, with strongly S-shaped frontal carinae and broad, diverging lobes, which are rounded anteriorly (larger than in the typical form).   Frontal area short and broad.   Lobe of the scape nearly right-angled, at the apex with a small projection.   Epinotal spines moderately long, somewhat horizontal and diverging.   Pedicel similar to that of var. *sancta*.

Head coarsely, but not very deeply, somewhat irregularly, rugose and reticulate on the sides; between the coarse rugosities are finer and more abundant, almost contiguous, punctations.   Thorax coarsely rugose longitudinally; declivous surface of epinotum smooth and shining. Pedicel somewhat less coarsely rugose and finely punctate.

Color dark red-brown; antennae, legs, apex of the gaster and a few blotches on the thorax somewhat lighter, ferruginous.

Type Locality.   Taganrog, 8.VI.1926 (K. Ahnger).

Head oval, slightly more narrowed posteriorly than anteriorly, at the sides moderately convex. Mandibles opaque and striate. Clypeus slightly rounded anteriorly to the middle; on the postero-median convex portion with five to six equidistant rugae, not connected to one another. Frontal area smooth, or, posteriorly, with a few rudimentary striae. Scape striate-punctate and opaque; exceeding the posterior margin of the head a little, at the base strongly curved and with a rounded lobe on the outside margin.   Third joint of the funiculus much shorter than the second; remainder of the antennae much as in those forms of the *scabrinodis* group.   Front relatively narrow; the more narrowed at about the middle where it is nearly equal to four-fifths of the length of the frontal lamina.   This is distinctly arcuate.   Thorax rather elongate, with well marked mesoepinotal impression.   Epinotum equipped with somewhat slender spines, as long as, or a little less, twice the distance between their bases, almost horizontal and little diverging, extending to about the middle of the petiole.   Petiole with a short peduncle and a node visibly angulate in profile.   Postpetiole narrowed anteriorly, longer than broad and moderately rounded at the sides; seen from the side the maximum convexity is posterior.

Type Locality.   SIBERIA: Verkneudynsk (H. Eidmann).

"This *Myrmica* belongs to the *scabrinodis* group but differs from the subspecies *angulinodis* and *kasczenhoi* described by Ruzsky from Siberia and Transbaikal; rather are points of resemblance found with *saposhnikovi*, described from the Altai Mts. by the same author, but differs in slightly larger size, by the more conspicuous lobe of the scape and in consequence the more narrow front, and by the more abundant fine pilosity."

Myrmica scabrinodis subsp. granulinodis Nylander

M. granulinodis Nylander, 1846, Act. Soc. Sc. Fennicae, 1846: 1060, ♀.

Female (after Nylander):—Quite similar to the female of *M. scabrinodis* but the antennal scape is entirely geniculate at the base, not (anteriorly?) excavated, frontal laminae a little less dilated on both sides, nodes of the pedicel somewhat reddish, densely granulose-rugose; legs pubescent (to sparsely decumbent pilose) as in the *scabrinodis* female.   Male similar to the male of the same, scape at the base a little curved, one-third the length of whole antenna, a little exceeding, to as long as, the seven following joints, funicular joints moderately pilose, the ultimate ones a little more coarsely, all the antennal joints somewhat longer than in *M. ruginodis*, legs almost bare, thinly pubescent; pleura and metanotum somewhat longitudinally striate; wings as in the female, more dilute than in *scabrinodis*, nerves and stigma pale cinereous.

Type Locality.   "Siberia."

Myrmica scabrinodis subsp. kaszenkoi Ruzsky

M. scabrinodis subsp. *kaszenkoi* Ruzsky, 1905, Formic. Imp. Rossici, pp. 702–703, ♀ ♂.

Worker (after Ruzsky):—Length 4–5 mm.

Antennal scape cylindrical, abruptly bent at the base in the form of an even angle (as in *rugulosa* or *sulcinodis*); at the bend a small

extension. Sculpturing of the head about as in *scabrinodis*. Frontal surface of head striate. Mesoepinotal impression not large. Epinotal spines short, pointed, somewhat broad at the base, almost straight, not diverging, as long as the width of the space between them; infraspinal surface finely striate on the upper part. Petiole short, thick (about as in *scabrinodis*), the node, from above, somewhat tapering, with rounded corners; anterior declivity somewhat concave, posterior declivity somewhat convex. Pedicel dull, finely wrinkled, thickly and finely punctate, on the sides weak longitudinal furrows. Pilosity somewhat dense, on the legs and antennae short, inclined on the thorax and petiole, somewhat lighter (yellowish-brown red); sometimes darker on the dorsal surfaces of the thorax, except posteriorly.

Male (after Ruzsky):—Very close to *rugulosa*. Antennal scape very weakly bowed, short, not longer than the three following joints together. The 1st funicular segment almost equal to the third, the second less than 1½ times longer than the first. Club five-jointed. Head and frontal surface finely punctate; on the frons and clypeus fine, thin striae. Pilosity of the tarsi, color and body length as in *rugulosa*.

"This *Myrmica* stands, on the one hand, near *M. scabrinodis* and *rugulosa*, and, on the other hand, it is referable in the form of the antennal scape and the short petiole to *M. brevinodis* Em."

Type Localities. Transbaikal, Yenisesk.

Myrmica scabrinodis var. lacustris Ruzsky

M. scabrinodis var. *lacustris* Ruzsky, 1905, Formic. Imp. Rossici, p. 686, ☿.

Worker (after Ruzsky):—Anterior medial margin of the clypeus with a small incision. Frontal area striate posteriorly. Antennal scape at the bend with a small sharp tooth. Mesoepinotal impression weak, the thorax, in profile, flatter than in the typical *scabrinodis*. Sculpturing of the body weaker. Epinotal spines one-half to two-thirds as long as the basal surface. Color as in the type but the gaster is quite dark brown, except at the apex.

Type Locality. Tobolsk.

"This *Myrmica* nests in small sized colonies in earth mounds, similar to those of *Lasius flavus* and *niger*. The mounds were stripped of leaves. In one *Myrmica* mound *Lasius flavus* inhabited the other end. Very possibly the *Myrmica* in most cases does not build such a mound but moves into one being deserted by the *Lasius*."

Myrmica scabrinodis subsp. mexicana Wheeler

M. mexicana Wheeler, 1914, Jour. New York Ent. Soc., 22: 52–53, ☿ ♀ ♂; Wheeler, 1917, Proc. Amer. Acad. Arts Sc., 52: 503.

Original Descriptions.
"*Worker:*—Length 3.5–5 mm.

"Closely allied to the European *M. sulcinodis* Nyl. Head distinctly longer than broad. Antennal scapes shaped like those of *sulcinodis* or rather of the var. *sulcinodis-scabrinodis* Forel, being a little more sharply bent at the base and in some specimens with a small tooth or ridge at the angle as in some forms of *scabrinodis*. The joint is of nearly uniform thickness throughout. Funiculi with a 3-jointed club,

which in some specimens, seems to be indistinctly 4-jointed. Spines of the epinotum straight or very slightly bent downward, somewhat shorter than those of *sulcinodis* and not recurved at their tips. Petiole in profile a little longer than high, shaped as in *sulcinodis*, not pedunculate, its node with subequal declivities, the anterior feebly concave, the posterior feebly convex, both meeting at a rather sharp angle. Postpetiole also as in *sulcinodis*, distinctly higher than long.

"Sculpture very coarse and much as in *sulcinodis*, with shining interrugal spaces, but the longitudinal trend of the rugae is not so distinct on the thorax and pedicel, often vermiculate on the thoracic dorsum and the nodes. Frontal area rugose, opaque.

"Hairs like those of *sulcinodis*, but of a gray instead of a yellow tint.

"Deep cherry red, legs a little darker; gaster, clypeus and anterior half of head, black. In many specimens the whole head and thorax are dark brown or blackish.

"*Female* (dealated):—Length 5.5 mm.

"Closely resembling the worker and differing greatly from the female *sulcinodis* in color, being like the darkest workers, with the upper surface of the thorax and the whole head blackish.

"*Male:*—Length 5–5.5 mm.

"Differing from the male of *sulcinodis* in its larger size and in color, the body being deep black, with only the legs and genitalia piceous, and the 4–5-jointed clubs of the antennae and tips of the mandibles clear yellow. The wings are more grayish and longer (6 mm.), whereas those of *sulcinodis* measure less than 5 mm., and the veins and stigma are of a deeper brown tint. The antennal scapes resemble those of *sulcinodis*, being fully half as long as the funiculi, and equal to the 6–7 following joints together, but are somewhat stouter, especially at the base. There are no appreciable differences in pilosity between the two forms. In sculpture the following differences may be noted: the petiolar node is irregularly rugulose-punctate, not longitudinally rugose as in *sulcinodis* and the postpetiole is also smoother and more shining; the fine rugae on the head are more irregular and not longitudinal.

"Described from many workers and males and three females taken from several colonies at Guerrero Mill. These colonies were found under stones, both in the pine woods and on the open hillsides."

This *Myrmica*, taken by Dr. W. M. Mann at an altitude of 8,500–9,000 feet on the eastern slope of the mountain range east of Pachuca, the capital of the State of Hidalgo, Mexico, is of unusual interest. Coming as it does from 20° North Latitude, well within the Tropic of Cancer, it is by far the most southern *Myrmica* recorded in the Western Hemisphere.

It also combines characters of *M. sulcinodis* and *M. scabrinodis*, as Dr. Wheeler has pointed out. The study of the male genitalia proves it closer to *scabrinodis* than to *sulcinodis* and the long scape of the male (equal in length to from six to seven of the following segments together) links it to *scabrinodis lobicornis*, as does the occasional transverse ridge at the base of the worker scape.

Other Localities. ARIZONA: Ramsay Canyon, Huachuca Mts. (W. S. Creighton); Santa Rita Mts., 7500 ft., Santa Catalina Mts., 7700 ft. (L. F. Byars).

Myrmica scabrinodis subsp. rolandi Bondroit

M. rolandi Bondroit, 1918, Ann. Soc. Ent. France, 87: 101, ☿ ♀ ♂; Finzi, 1926,
   Boll. Soc. Adr. Sc. Nat., Trieste, 29: 89–90.
M. scabrinodis st. *rolandi* Santschi, 1931, Rev. Suisse Zool., 38, p. 344.

Southern France, Iberian Peninsula, Morocco.
For descriptions and discussions of this form see the references above.
This is one of the three recorded forms from North Africa.

Myrmica scabrinodis rolandi var. reticulata Santschi

Myrmica scabrinodis st. *rolandi* v. *reticulata* Santschi, 1931, Rev. Suisse Zool.,
   38: 344, ☿.

Central Pyrenees.
For a description of this form see the above reference.   Apparently
differs only in having the appendages more dull colored.

Myrmica scabrinodis subsp. rugulosoides Forel

M. scabrinodis var. *rugulosoides* Forel, 1915, Fauna Insect. Helvet. Hym. Form.,
   p. 29, ☿; Santschi, 1931, Rev. Suisse Zool., 38: 342–343.
M. rugulosoides Finzi, 1926, Boll. Soc. Adr. Sc. Nat., Trieste, 1926: 94–95, fig. 6,
   ☿ ♀ ♂.
M. specioides Bondroit, 1918, Ann. Soc. Ent. France, 87: 102.

Central Europe.
For descriptions and discussions of this form see the references above.

Myrmica scabrinodis rugulosoides var. striata Finzi

M. rugulosoides var. *striata* Finzi, 1926, Boll. Soc. Adr. Sc. Nat., Trieste, 29: 96,
   fig. 7, ☿ ♀ ♂.
M. scabrinodis st. *striata* Santschi, 1931, Rev. Suisse Zool., 38: 344–345.

For descriptions and discussions of this form see the references above.

Myrmica scabrinodis var. sancta Karawajew

M. scabrinodis var. *sancta* Karawajew, 1926, Mem. Acad. Sc. Ukraine, 4: 67, 68,
   fig. 4, ☿; Karawajew, 1926, Konowia, 5: 285.

Worker (after Karawajew):—Length 4–4.5 mm.
Occipital margin scarcely concave in the middle. Frons broader
than in the typical form, in the middle broader than one-third of the
breadth of the head, the frontal carinae more strongly S-shaped, the lobes
clearly broader and much more rounded anteriorly. Scape bent under
45° at the base, forming a blunt angle. On the thoracic profile the
metanotum shows clearly. Epinotal spines somewhat shorter than in
the typical form. Petiole, in profile, with curved upper and lower
margins. Postpetiole convexly produced above and below.
Strongly wrinkled, the wrinkles, especially on the head, dark colored.
Infraspinal declivity of the epinotum somewhat smooth and shining,
barely striate. Pedicel clearly rugose longitudinally.
Moderately darkly colored.
Type Locality. KRIM: Neighborhood of Karadagh, not far from
Theodosia, 10.V.1920 (Karawajew).
The colony was under a large flat rock on the peak of a "Holy
Mountain."

Myrmica scabrinodis subsp. saposhnikovi Ruzsky

M. scabrinodis saposhnikovi Ruzsky, 1905, Formic. Imp. Rossici, pp. 701–702. fig. 171, ☿.

Worker (after Ruzsky):—Length 3.6–4.5 mm.

Antennal scape bent as in *lobicornis*, at the bend with a moderately sized blunt tooth (much as in *fracticornis* Emery), clearly surpassing the occipital margin. Third funicular joint the smallest, about as long as broad, club four-jointed. Head a long oval with strongly curved occipital corners. Thorax, in profile, moderately convex, mesoepinotal impression weak. Petiole very short; almost lacking a cylindrical peduncle, node with sharply rounded corner, anterior declivity somewhat depressed in the middle. Head, thorax and pedicel dull. Petiole coarsely and irregularly wrinkled, postpetiole broadly sulcate with slight wrinkles between (in the var. *fracticornis* the petiole is less wrinkled and the form quite different). Epinotal spines thin, strong, shorter than the basal surface, as long as the distance between their bases, somewhat curved, weakly diverging. Infraspinal surface almost smooth, shining. Frontal area smooth, somewhat shining. Thorax coarsely wrinkled.

Color blackish brown, appendages and apex of gaster lighter, scape dark, petiole sometimes with a reddish cast.

Type Locality. MIDDLE ASIA: Semiridje in the Altai Mts., 1,000 m.; in a dense fir forest.

"Distinct in the length and narrowness of the antennal scape; similar in that to *fracticornis* and *stangeana*; in epinotal spines and sculpture near to *lobicornis*."

Myrmica scabrinodis saposhnikovi var. baikalensis Karawajew

M. scabrinodis saposhnikovi var. *baikalensis* Karawajew, 1931, Zool. Anz., 93: 28, 29, ☿ ♀.

Worker (after Karawajew): Length 3.5–4 mm.

The little tooth on the corner of the bend of the scape can hardly be perceived, in the smallest specimens (somewhat dimorphic) even quite absent. The mesoepinotal impression is very clear (in the type weakly indicated), the promesonotum, in profile, somewhat convex. The epinotal spines are somewhat more erect, hardly bent inwardly.

Female (after Karawajew): Length about 5 mm.

Head as in the worker, somewhat longer than broad, with even occipital margin in the middle. Frons even broader than in the worker, with less curved frontal carinae. Frontal area not quite smooth. The antennal scape hardly exceeds the occipital margin, without a tooth at the angle of the bend.

Thorax comparatively shorter and thicker than in the worker. In profile the posterior half of the mesonotal scutum and the anterior half of the scutellum form an even line. Epinotal spines as in the worker; frontal area likewise. The wings are lacking in my single example. Otherwise similar to the worker.

Type Localities. Shore of Lake Baikal: Listwenitschnoje, 15.VII. 1930, Tanchoj-Mischicha (eastern shore, southern part), 1–6.VIII.1930, (W. Karawajew).

Myrmica scabrinodis subsp. stangeana Ruzsky

M. bergi stangeana Ruzsky, 1902, Zool. Jahrb. Syst., 17: 474, ☿; Ruzsky, 1905, Formic. Imp. Rossici, p. 678, ☿.

Worker (cotype):—Length 4.9 mm. (3.5–5 mm. after Ruzsky).

Head 0.67 as broad between the eyes as long (with mandibles), occipital margins almost imperceptibly concave in the middle (in strictly dorsal view) occipital corners evenly rounded, eyes slightly closer to the anterior clypeal than to the occipital margin; anterior clypeal margin very slightly convex; antennal scapes exceeding the occipital margin a little; in a posterior view bent almost at right angles near the base and distinctly compressed obliquely to its long axis, no clear dorsal carina but a slight indication of a keel at the bend; joints 1 and 2 of the funiculus together about equal to joints 3 to 5 together, club indistinctly four-jointed. Thorax, in profile, evenly convex to the moderately impressed mesoepinotal suture; epinotal spines straight, slender and acute, projected backwards and upwards at about 45°, about as long as the declivity ventral to them, seen from above, indistinctly longer than the distance between their bases (one spine being clearly shorter than its mate). Petiole, in profile, short, anterior face almost imperceptibly concave, slightly higher than the distance between the apex of the ventral tooth and the postpetiole. Postpetiole, in profile, distinctly higher than the petiole or than it is long, highly convex dorsally, slightly convex ventrally. Gaster subelliptical. Legs moderately long, somewhat robust.

Dorsal medial surface of head, including the cylpeus, regularly rugulose, sides reticulate-rugulose, frontal area smooth and shining but for several striae entering the posterior angle; densely and conspicuously punctate at the base of the sculpturing. Dorsal surface of thorax coarsely and longitudinally vermiculate, sides rugose, infraspinal surface of epinotum clearly and transversely striate. Dorsal surface of petiole coarsely and irregularly reticulate-vermiculate, sides rugose-punctate. Dorsal median area on postpetiole striate-punctate, surface otherwise rugose-punctate. Gaster, at the base, joined to a peduncle by very short ridges, otherwise microscopically reticulate and shining. Antennal scapes finely but completely, legs sparsely, striate-punctate.

Pilosity of body short, sparse, rather coarse, mostly truncate dorsally except on the head; on appendages short, reclining, rather coarse. Short appressed pubescence on the antennal club, almost absent from the two basal joints.

Color reddish brown, dorsal surface of head a little darker, gaster dark brown.

Type Locality. Kirgisen Steppes of Turgai: Lehmboden (G. Stange).

The ants were "wandering amongst *Artemesia* and live in groups in the ground."

Myrmica scabrinodis variety turcica Santschi

M. scabrinodis var. *turcica* Santscyi, 1931, Rev. Suisse Zool., 38: 343, ☿ ♀.

Worker (after Santschi):—Length 4.2–4.6 mm.

Antennal scape with an acute lobe as in *sabuleti*, epinotal spines as long as in typical *scabrinodis*.

Myrmica ravasinii Finzi

M. ravasinii Finzi, 1923, Boll. Soc. Ent. Ital., 55: 2, ♀; Finzi, 1926, Boll. Soc. Adr.
Sc. Nat., Trieste, 29: 112-113, fig. 15.

For a description and discussion of this species see the references
above.

The gaster of a single worker sent me by Mr. Finzi is distinctly,
though finely, reticulate and somewhat striate-reticulate at the base.
This character is not mentioned by Mr. Finzi and, if it is common to
the other type specimens, marks the ants as very distinct. The frontal
carinae in the specimen are relatively close-set and the antennal scape,
from above, is broadly spatulate at the bend.

Myrmica wheeleri Weber

M. wheeleri Weber, 1939, Lloydia, 2: 150-152, ♀ ♀ ♂.

Worker:—Length 3.3-4.2 mm.

Head, between eyes, 0.67 as wide as long (with mandibles); occipital
margin straight; anterior clypeal border produced over base of mandibles
in about a 130° lobe. Antennal scape exceeding the posterior margin
of the head by a distance equal to its distal diameter; from above, in
the form of a long drawn-out sigmoid curve, from a posterior view,
evenly bent at its basal fourth about 0.6 as wide proximally as distally;
joints 1 and 2 of the funiculus together equal in length to joints 3 to 5
together; club three-jointed, terminal joint equal in length to the
preceding two joints together. Thorax, in profile, convex, with a
slight but distinct mesoepinotal suture; epinotal spines, in profile,
triangular with deflected apex, projected backwards and upwards at
about a 45° angle, appreciably shorter than the declivity ventral to
them, from above, about as wide as the distance between their bases,
widely diverging. Petiole, in profile, with distinctly concave anterior
face forming a sharp 90° angle with the convex dorsal surface; ventral
surface concave, shorter from apex of ventral tooth to postpetiole than
it is high; postpetiole, in profile, slightly higher than the petiole and
higher than long, dorsal and ventral surfaces convex, the ventral
convexity produced anteriorly as a lobe. Gaster ovate. Legs moder-
ately long and slender.

Surface of head finely sculptured and shining, clypeus very sparsely
and irregularly rugose, shining, frontal area triangular, smooth and shin-
ing, mid-dorsal surface longitudinally rugulose, becoming reticulate
laterally and posteriorly. Thorax feebly sculptured, shining, with
large, irregular vermiculations dorsally, feeble and sparse vermiculations
on the sides. Petiole feebly vermiculate-reticulate on the node; post-
petiole dorsally smooth and shining, laterally with a few irregular
vermiculations. Base of the sculpturing of body, except gaster, densely,
though shallowly punctate. Gaster, antennae and legs smooth and
shining.

Pilosity comparatively abundant and fine, mostly truncate dorsally,
subappressed on the legs; pubescence only on the antennal funiculi.

Color varying from light to dark ferruginous, head brown to dark
brown, gaster with a broad, dark, transverse band across the middle.

Female:—Length 4.5-5.2 mm.

Closely resembling the worker. The epinotal spines vary in length from worker size and shape to shorter, blunt teeth. The petiole is higher and more distinctly separated into node and peduncle.

The sculpturing is appreciably coarser, the pronotum, on the sides, reticulate, rugose only at the posterior margin, thoracic sides otherwise rugose, scutum of mesonotum shining, with anteromedial triangular area punctate, otherwise feebly vermiculate, becoming more rugose posteriorly.

Color darker; head, thorac and transverse band across gaster dark brown; pedicel and appendages ferruginous. The thorax in several is ferruginous with brown blotches. Wings hyaline; veins pale brown, stigma large and pale brown in color.

Male:—Length 3.6–4.3 mm.

Antennal scape equal in length to the following three segments together, subcylindrical, about one-fourth as wide as long, bent slightly at the base; funicular club four-jointed. Epinotal declivity dorsally with two slight, rounded gibbosities. Petiole, in profile, distinctly arched, anterior and ventral surfaces slightly concave, dorsal surface convex, slightly longer from apex of ventral tooth, or gibbosity, to postpetiole than it is high; postpetiole about one-third higher than petiole and distinctly higher than long. Sagittae of the genitalia with about 17 serrations; volsellae as illustrated, unique in the absence of a medial tooth inside the hook.

Surface of the head finely and evenly punctate, nearly devoid of rugosities. Thorax largely punctate, smooth and shining mid-dorsally, a few scattered rugae on the sides; petiole punctate, with sparse, feeble rugae. Postpetiole and gaster smooth and shining.

Pilosity sparse, fine, acute.

Color brown, dark brown on the dorsal surfaces of the head and thorax. Wings hyaline with a purplish sheen; veins pale gray, stigma large and gray in color.

Described from two colonies collected by Dr. W. M. Wheeler, July 26 and 27, 1917, on Mt. Lemmon, 8–9,150 feet and at Stratton, 6–7,000 feet, in the Santa Catalina Mts., ARIZONA.

This species could easily have been taken for a small form near *M. brevinodis* subsp. *brevispinosa* were it not for the utterly different volsellae of the male genitalia. The sculpturing of the worker and male is finer than in any other North American *Myrmica;* the short epinotal spines of the worker differ from those of *brevispinosa* in being stouter and deflected, resembling, in profile, the horns of *Bison bison*, the American buffalo.

The examination of hundreds of male genitalia and the uniformity in general habitus and size within a species convinces me that this ant can only be regarded as a distinct North American species. The volsellae of the genitalia are distinct from those in any other *Myrmica* and closest to those of *M. moravica* Soudek from Southern Europe.

Myrmica moravica Soudek

M. moravica Soudek, 1922–23, Act. Mus. Moraviensis, Brno, 20–21: 106, 6. fig. ☿ ♀; Soudek, 1925, Ent. Rec., 37: 34–35, Pl. 4, figs. 1–3, ☿ ♀ ♂; Finzi, 1926, Boll. Soc. Adr. Sc. Nat., 29: 104–105.

Worker (cotypes):—Length 5–6.5 mm.

Head about 0.6 as broad between the eyes as long (with mandibles), occipital margin, in strictly dorsal view, very slightly impressed medially, occipital corners evenly rounded; frontal laminae raised, auriculate; antennal scapes extending to the occipital margin or slightly exceeding it; seen from a posterior view, with outer margin bent nearly at right angles at the base, the medial side being flat and produced posteriorly as a carina, the carina being produced dorsally and appearing in this view as an acute tooth, from above appearing as a transverse keel; joints 1 and 2 of the funiculus together a trifle shorter than joints 3 to 5 together, third joint about as broad as long, club indistinctly four-jointed. Thorax, in profile, convex, almost imperceptibly impressed at the mesoepinotal suture; epinotal spines projected backwards and upwards at about 55°, longer than the distance to the episternal spines but much shorter than the whole declivity. Petiole, in profile, with slightly concave anterior face, a little longer from apex of ventral tooth to postpetiole than it is high; petiolar-postpetiolar junction much constricted. Postpetiole, in profile, slightly higher than the petiole, ventral margin slightly, dorsal margin highly, convex. Gaster ovate. Legs of moderate proportions.

Surface of head coarsely and sharply reticulate-rugose, clypeus irregularly rugose, frontal area punctate with a few striae, base of sculpturing shining irregularly and shallowly punctate. Thorax deeply rugose, somewhat vermiculately anteriorly; infraspinal surface of metanotum shallowly and transversely striate. Dorsal surface of petiole deeply and irregularly vermiculate-punctate, sides rugose. Postpetiole rugose-punctate but for a finely reticulate mid-dorsal area. Gaster smooth and shining, at the junction with a short peduncle are a few inconspicuous short ridges. Antennal scapes striate, legs microscopically reticulate.

Body with comparatively abundant pilosity, appendages with abundant subappressed hairs; antennal club sparsely pubescent, almost lacking on the basal (fourth) joint.

Color dark reddish brown, darker on the dorsal surface of the head and gaster.

Female (cotype):—Length 7 mm.

Similar to the worker. The epinotal spines are of comparable length and are stout and blunted. From a narrow antero-median, largely smooth, area on the scutum of the mesonotum several rounded rugae extend, these are bordered laterally by rounded vermiculations, sides of thorax deeply rugose, infraspinal surface of epinotum smooth; pedicel as in the worker, except the mid-dorsal smoother area on the postpetiole is much reduced. Color as in the worker, the thorax with several darker brown blotches; including a parapsidal pair on the scutum of the mesonotum but no antero-median blotch.

Male (cotype):—Length 6 mm.

Antennal scapes subcylindrical, slightly smaller and bent gently at the basal third, as long as the two following joints of the funiculus together; antennal club four- to five-jointed. Epinotal declivity with two rounded dorsal gibbosities. Petiole with evenly convex dorsal margin and nearly straight ventral margin, without a tooth. Postpetiole, in profile, distinctly higher than the petiole, as long as high,

with nearly straight ventral and convex dorsal margin. Sagittae of the genitalia with greatly reduced medial tooth.

Surface of head dully shining, very finely punctate striate. Dorsal surface of thorax shining, sparsely rugulose on the margins, sides mostly rugulose-punctate. Petiole shining, microscopically striate-punctate. Postpetiole and gaster smooth and shining.

Pilosity sparse, more abundant and finer on the appendages.

Color dark brown, nearly black on the head.

Type Locality. CZECHOSLOVAKIA (South Moravia); Pavlovske Kopce (S. Soudek).

The male genitalia of this ant show that it must be considered a distinct species. In the great reduction of the median tooth on the volsella it approaches the condition in the American *Myrmica wheeleri* and is distinct from any *M. scabrinodis* form examined; the reversed serrations on the sagittae of my cotype are unique and might be an individual anomaly, for in Soudek's figure they are shown normally. The worker, in the coarseness of sculpturing, is similar to another American *Myrmica*, *M. punctiventris* Roger.

Myrmica punctiventris Roger

M. punctiventris Roger, 1863, Berlin Ent. Zeitschr., 7: 190, ♀; Mayr, 1886, Verh. Zool. bot. Ges. Wien, 36: 450; Emery, 1895, Zool. Jahrb. Syst., 8: 312, ♂; Wheeler, 1905, Bull. Amer. Mus. Nat. Hist., 21: 383; Wheeler, 1910, "Ants," p. 566.

M. punctiventris var. *isfahani* Forel, 1922, Rev. Suisse Zool., 30, p. 92, ♀ ♀.

Worker:—Length 4–4.7 mm.

Antennal scape bent inwards at about a 45° angle at the basal fourth, basal diameter over half the distal diameter, scapes extending a little beyond the occipital margin; thorax in profile with a deep mesoepinotal notch, that part of the thorax anterior to the notch appreciably higher than that part posterior; epinotal spines directed at about a 45° angle backward and upward from the epinotum, about 1½ times in length the distance between their bases, divergent, acutely pointed, and deflected at the tips; petiole in profile 1½ times as long as high, anterior face concave, dorsal and posterior surfaces convex, median ventral tooth short, extending to under the epinotal lamina. Postpetiole in profile nearly twice as high as long, dorsal surface eccentrically convex, seen from above transversely elliptical but only slightly broader than long. Gaster long-ovate. Legs long, femur and tibiae incrassate, 1st tarsal joint of mesothoracic leg longer than the four following joints.

Surface of the head very coarsely sculptured, medial dorsal surface, including the clypeus and sides of the frontal area, the sides anterior to the eyes, and the back longitudinally rugose, sides posterior to the eyes irregularly reticulate; surface of the thorax coarsely and somewhat irregularly rugose; pedicel coarsely vermiculate, somewhat smoother on the median dorsal surface of the postpetiole; interrugal surfaces finely punctate; gaster smooth and shining but for conspicuous, large, deep punctures which are more numerous basally.

Hairs of head and thorax of moderate length, scanty, those of gaster more numerous; hairs of appendages more numerous and subappressed.

Color of body red-brown, darker on the head and gaster, lighter on the appendages; head and gaster in some specimens approaching black in color.

Female (undescribed):—Length 5.0–5.7 mm.

Very similar to the worker, with fully as long epinotal spines and as coarse sculpturing. The pronotum and the anterior part of the mesonotum are vermiculate, the remainder of the thorax more regularly rugose; the gastric punctures are coarse and conspicuous; the body is dark brown with lighter red-brown appendages.

Male:—Length 3.8–4.8 mm.

Antennal club five-jointed; antennal scape long, slender, subcylindrical, bent at the basal fifth in about a 30° angle, equal in length to the six following joints together; petiole from the side pyriform, with smoothly rounded dorsal surface; postpetiole from the side perpendicularly elliptical, from above subcircular and nearly twice as broad as the petiole. Sagittae of the genitalia with about 24 serrations; volsellae as illustrated. Surface of the head with sparse, shallow and irregular vermiculations, densely punctate between the vermiculations; surface of the thorax and petiole feebly and irregularly rugose with dense punctations interrugally; postpetiole mostly smooth and shining or finely striate-punctate; gaster smooth and shining but for large, shallow and inconspicuous punctations. Hairs fine, pale yellow and scanty, even on the head. Wings hyaline with a faint brownish tinge; veins pale brown. Color dark brown to black.

Type Locality. "North America" (Roger).

Other Localities. MASSACHUSETTS: Naushon Island (W. S. Creighton, W. M. Wheeler); Woods Hole (A. H. Sturtevant, W. M. Wheeler); Forest Hills, Boston and Blue Hills (N. A. Weber, W. M. Wheeler); S. Wellfleet (N. A. Weber). NEW YORK: Cold Spring Harbor, Long Island (W. M. Wheeler); Flatbush, L. I. (T. Pergande). NEW JERSEY: Alpine, Newfoundland, Fort Lee (W. M. Wheeler); Riverton (U. S. N. M); Watchung Mts. near Westfield (C. R. Mekeel, N. A. Weber). PENNSYLVANIA: Beatty (P. J. Schmidt); St. Vincent (U. S. N. M.). DISTRICT OF COLUMBIA: Washington (Pergande Coll., W. M. Mann, N. A. Weber), Tacoma (Pergande Coll., W. M. Mann). MARYLAND: Plummers Island (W. M. Mann, U. S. N. M.); Beltsville, (W. L. McAtee). VIRGINIA: Loft Mt., 2452 ft., Shenandoah Nat. Park (N. A. Weber). NORTH CAROLINA: Black Mountains, (no collector); Durham (N. A. Weber). GEORGIA: Tray Mountain, White County (M. R. Smith). OHIO: Willard (M. Talbot); Southcent. Region (L. G. and R. G. Wesson); Ashtabula Co. (A. E. Headley). ILLINOIS: Champaign (A. O. Weese, T. H. Frison); Hickory Creek (M. Talbot). IOWA: Belle Plaine (W. F. Buren). MICHIGAN: Charity Island (Gaige). TENNESSEE: Gt. Smoky Mts. (A. C. Cole, M. Talbot).

The sexual forms appear in Massachusetts Aug. 30 to Sept. 8; in Georgia Sept. 11; in Washington, D. C., Oct. 3.

The coarse sculpturing and the gastric punctations easily distinguish the workers of this species from all other known forms. The genitalia of the male are unique in the possession of a series of pointed tubercles on the outer margin of the base of the volsellae; these appear in side view as serrations. Other species may possess a few small and inconspicuous

tubercles at this place but in no other species examined is there such a
development.

The colonies are small and are generally found under stones in wooded
areas. The workers sometimes become temporarily immobile when
handled or disturbed. Wesson and Wesson report them nesting only
in soil in Ohio and often surmounting the entrance with a turret of
crude carton.

The variety *isfahani* Forel has been synonymized because of the
inadequacy of the original description. Several of the characters given
are those of the typical form; the others agree well with slight variants
present in the collection from different localities. To follow the practice
of naming these slight variants would necessitate the erection of innu-
merable varieties in the North American members of the genus alone.
The minimum size given for the female is smaller than that of any
females I have seen and smaller than that of other females from the
same region.

Myrmica punctiventris subsp. pinetorum Wheeler

Myrmica punctiventris subsp. *pinetorum* Wheeler, 1905, Bull. Amer. Mus. Nat.
   Hist., 21: 384, ♀; Wheeler, 1910, "Ants," p. 566.

Worker:—Length 3.5–3.9 mm.

Similar to the typical form but differing in the following character-
istics: Smaller size; epinotal spines, from above, acute and diverging,
slightly longer than the distance between their bases, averaging one-
fourth shorter than those of the typical form; seen from the side, directed
upward and backward at a 45° angle, not deflected apically; sculpturing
finer, especially on the head; color paler, averaging medium brownish
red on the head and middle part of the gaster and a light brownish red
on the remainder of the body and on the appendages.

Female (undescribed):—Length 4.7–5.1 mm.

Similar to the female of the typical form. The sculpturing of the
head, however, is less regularly longitudinal; the epinotal spines are
of nearly the same length but are not deflected downward; the color is
paler, parts of the thorax, the pedicel and the appendages being a pale
brownish red, the remainder of the body being dark brown. Wings
hyaline with a brownish cast; veins pale brown.

Male (undescribed):—Length 3.9–4.3 mm.

Easily separated from the male of the typical form by the short
antennal scape which is equal to only the first two of the following
joints together, is subcylindrical, and is almost imperceptibly bent
medially; the antennal club is four-jointed. The petiole is also not
pyriform but with an irregularly convex dorsal and a distinctly concave
ventral surface; the postpetiole is highest at the posterior half; the
sagittae with 20 to 21 serrations, the volsellae as illustrated. Gaster
finely punctate with coarser setigerous punctations. The color is a
deep brown, not black.

Type Locality. NEW JERSEY: Lakehurst (W. M. Wheeler).

Other Localities. CONNECTICUT: Colebrook (W. M. Wheeler).
OHIO: Southcent Region (L. G. and R. G. Wesson). TENNESSEE:
Tusculum, Greenville (C. A. Dennis). SOUTH CAROLINA: Clemson
College (M. R. Smith). MISSISSIPPI: Starkville (M. R. Smith).

The winged forms appeared August 19 in Connecticut; no other records seen.

Dr. Wheeler found this colony nesting in pure sand in the pine barrens. Wesson and Wesson report the ants building carton turrets as nest entrances. A nest reported by Dennis was in a small log, the brood being in a cavity in the wood.

The South Carolina record is from two workers, sent me by Dr. Smith, which are a little larger and darker than the average form and with slightly different thoracic rugae. More workers and the males are necessary to determine whether they represent a distinct form.

Myrmica myrmecoxena Forel

M. myrmecoxena Forel, 1894, Verh. 66 Versamml. D. Naturf. Aerzte, Wien, p. 143; Finzi, 1926, Boll. Soc. Adr. Sc. Nat., Trieste, 29: 114, ♀.

Female (after Emery):—Length 4.3 mm. (almost 5 mm., after Forel).

Distinctive by the short, compact form and the weak sculpture. Head especially short, shorter than in *scabrinodis* or its forms. Antennae short and thick; scape at the basal fourth obtusely geniculate, without a trace of thickening or of a tooth, hardly reaching to the occipital margin; club three-jointed. Mandibles broad, with 10 to 12 teeth, which, except for the two apical teeth, are very small. Epinotal spines short and robust. Petiole strikingly short and high. Postpetiole from below with a strong forwardly directed lobe.

Surface of the head somewhat smooth, dorsal surface longitudinally rugose, lateral surfaces rugose-reticulate, with conspicuous basal punctations; frontal area small, shining; frontal lamina as in *lobicornis*. Mesonotum smooth in the middle, without rugosities; the thorax otherwise dull and densely rugose; face of the epinotal declivity transversely striate. Petiole rugose. Upper part of postpetiole smooth and strongly shining.

Color ferruginous, posteriorly lighter; mandibles, antennal scapes, and legs dirty yellow; wings hyaline, with pale venation.

Male (after Forel):—Length 4.8 mm.

Antennal scape hardly as long as the first four segments of the funiculus; antennae and legs short. Epinotum with short teeth. Hairs on the tibiae long and almost upright. Color blackish-brown, shining; frontal area smooth and shining. Mesonotum from above smooth.

Nuptial flight in August (Finzi).

This peculiar form was collected by Professor Bugnion in the Swiss Alps with a colony of *Myrimca lobicornis* at an altitude of 2,000 meters. As Forel states, he was at first inclined to consider it an abnormal type of *lobicornis* but he later believed it to be a possible parasite. Genitalic slides of the males would quickly determine its position. The absence of workers and the small size, of course, suggest its parasitic nature. Neither Forel nor Emery mention a marriage flight of this form and the source of Finzi's information is unknown to me. It apparently has been taken only the original time.

Myrmica margaritae Emery

M. margaritae Emery, 1889, Ann. Mus. Stor. Nat. Genova, 27: 502, ☿.

Worker (after Emery):—Length 5-5¼ mm.

Piceous, antennae and epinotal spines rufotestaceous, legs and gaster testaceous, with very short and sparse pilosity. Head and thorax coarsely, irregularly, while longitudinally, rugose, occipital margin with a confused reticulate sculpturing, clypeus longitudinally rugose, mandibles striate; antennal scapes finely striate, at the base curved, antennal club four-jointed, mesoepinotal suture lightly impressed, epinotal spines still much longer and much more graceful than in the preceding (*M. ritae*) and similarly curved, likewise with minute spines on either side of the petiolar articulation, upper declivity of this segment concave, shining. Petiole feebly elongate, finely reticulate-rugose, almost shining; postpetiole finely and longitudinally striate-rugose, rather opaque; gaster shining, with sparse, minute piligerous punctations. Legs with short, oblique hairs.

Type Locality. MALAY PENINSULA: Tenasserim: Mt. Mooleyit, 1-1,900 m. (L. Fea).

Emery believed that the nearest form to this species and *M. ritae* was *M. rugosa* Mayr, which, however, is quite different in general habitus.

Myrmica margaritae subsp. inornata Menozzi

M. margaritae subsp. *inornata* Eidmann, 1942, Zeitschr. f. Morph. u. Ökol. Tiere, 38: 15.

Type Locality. WEST CHINA: Wasukou, 1600 m.

The original description of Menozzi has not been seen. Eidmann gives ecological information only. It is an Indomalayan form found near 30° North Latitude in an arid, subtropical district and workers were taken under a stone.

Myrmica margaritae var. pulchella Santschi

M. margaritae var. *pulchella* Santschi, 1937, Bull. Ann. Soc. Ent. Belg., 77: 368, ☿.

Worker (after Santschi):—Color as in *margaritae* but gaster with a large transverse band across the middle; black, with mandibles, legs, epinotal spines, base and apex of the gaster yellow; anterior border of head russet, antennae bright red.

Type Locality. FORMOSA: Musha.

Myrmica ritae Emery

M. ritae Emery, 1889, Ann. Mus. Stor. Nat. Genova, 27: 501-502, Pl. XI, fig. 27, ☿.

Head, between the eyes, about 0.6 as broad as long (with mandibles), eyes, in breadth, twice the diameter of the distal end of the antennal scape; anterior margin of clypeus slightly concave; antennal scapes exceeding the posterior margin of the head by one-fourth its length, slightly bent at its basal sixth, distal diameter 1½ times the basal diameter; antennal club four-jointed, joints 1 to 2 of the funiculus together distinctly shorter than joints 3 to 5 together. Thorax, in profile, feebly convex to the distinct and broad mesoepinotal impression;

epinotal spines, in profile, slender, acute, straight, projected backwards and upwards at about a 25° angle, about one-third longer than the declivity ventral to them; from above, fully three times as long as the distance between their bases, slightly diverging. Petiole, in profile, clavate, anterior face plane, dorsal surface convex, distinctly longer from apex of ventral tooth to postpetiole than it is high. Postpetiole, in profile, subconic, the posterior dorsal angle being convex, anterior face sloping to a slight peduncle, ventral surface slightly convex. Gaster ovate. Legs long and slender; first joint of mesothoracic leg about one-sixth longer than the following four joints together.

Surface of head shining, clypeus with six rugae between the frontal carinae, frontal area smooth and shining, remainder of head sharply and longitudinally rugose; interrugal surface smooth or with shallow punctations; mandibles rugose. Dorsal surface of thorax coarsely vermiculate, sides rugose, whole surface shining. Pedicel rugose, dorsal surfaces more irregularly and shallowly vermiculate-punctate. Gaster smooth and shining. Antennal scapes and legs finely striate-punctate.

Pilosity very sparse, a few long, truncate or acute hairs; appendages, except on the femora, with moderately abundant, subappressed hairs; antennal clubs pubescent.

Color of head rufous, antennae lighter, thorax and pedicel dark brown, gaster brown, legs yellowish brown.

Type Locality. MALAY PENINSULA: Tenasserim, Mt. Mooleyit, 1–1,900 m. (L. Fea).

The unusually long first tarsal joint of the mesothoracic leg separates this species from all others of the genus which I have been able to examine. This character is correlated with unusually long legs. Nothing seems to be known of its habits.

Myrmica ritae subsp. formosae Wheeler

M. margaritae var. *formosae* Wheeler, 1929, Boll. Lab. Zool. R. Ist. Portici, 24: 37, ♀.

Worker (cotypes):—Length 4.5–6.4 mm.

Head about 0.62 as broad between the eyes as long (with mandibles), occipital corners evenly rounded to a transverse margin posteriorly, eyes distinctly closer to the anterior clypeal than to the occipital margin, anterior clypeal border with a broad rounded medial notch, frontal carinae low, arcuate, sub-vertical; antennal scape slender, evenly bent at the basal seventh, exceeding the posterior margin by about four times its distal diameter; joints 1 and 2 of the funiculus together a trifle longer than joints 3 and 4 together, much shorter than 3 to 5 together; club four-jointed. Thorax in profile, feebly convex, deeply notched at the mesoepinotal suture; epinotal spines, in profile, acutely attenuate and upwards at about 25°, over 1½ times as long as the declivity ventral to them, from above, over three times as long as the distance between their bases, moderately diverging; metasternal lobes directed upwards and acute. Petiole, in profile, with a distinct peduncle which is convex dorsally, concave ventrally, nearly one-half longer, from apex of ventral tooth to postpetiole, than it is high, node feebly

and irregularly convex dorsally. Postpetiole distinctly higher than the petiole, a little longer than high, dorsal margin produced in a convex lobe at the posterior margin, ventral margin nearly flat. Gaster short ovate. Legs long and slender; first tarsus of mesothoracic leg nearly one-third longer than the second to fifth together.

Surface of head deeply, sharply and coarsely sculptured, clypeus rugose, the posterior margin smooth and confluent with the frontal area which is shining, microscopically punctulate and posteriorly margined by vertical walls; frontal carinae produced posteriorly as one of the rugosities, between them about four similar rugosities, sides of head more reticulate-rugose. Dorsal surface of thorax deeply vermiculate in a general longitudinal trend, sides more rugose, base of spines finely striate. Pedicel coarsely rugose-reticulate, including the dorsal surface which also may bear punctations and the ridges may be more or less fused, especially on the petiole. Gaster smooth and shining. Antennal scapes densely striate, legs microscopically reticulate.

Pilosity moderately abundant, hairs of the body long and acute, shorter on the gaster, appendages with more numerous, fine and oblique to subappressed acute hairs. Antennal club and tarsi pubescent.

Dorsal surface of head, "thorax, pedicel and posterior ¾ of the first gastric segment reddish piceous, pedicel somewhat darker; mandibles and antennae pale brown; cheeks, anterior portion of gula, legs and anterior ¾ of gaster ivory yellow."

Type Locality. FORMOSA: Funkiko (F. Silvestri).

Other Localities. FORMOSA: Riyohen, Karenko (R. Takahashi); Taiheizan (L. Gressit).

This subspecies differs from the typical *M. ritae* Emery chiefly in more irregular sculpturing, in paler coloration of the legs and in longer first tarsal joint compared to the following joints. It differs from the subsp. *serica* in sculpturing and in much paler coloration.

Both the subspecies *formosae* and *serica*, which were described as varieties of *M. margaritae* Emery, have been placed under *M. ritae* Emery after the comparison of them with a cotype of *ritae* and with the original figure of this species. The general habitus is the same. Judging from the original descriptions, *ritae* and *margaritae* must be much alike, but *margaritae* is described with minute metasternal spines and finely sculptured pedicel, certainly not characters of *formosae*, *serica* or *ritae*.

Myrmica ritae subsp. indica n. subsp.

Worker:—Length 5.3–5.6 mm.

Head about 0.66 as wide between the eyes as long (with mandibles), posterior margin feebly convex, occipital corners somewhat angular, eyes somewhat closer to the anterior clypeal than to the occipital margin, anterior clypeal margin evenly and broadly notched medially; antennal scapes slender, exceeding the posterior margin by fully twice their distal diameter, joints 1 and 2 of the funiculus together shorter than joints 3 to 5 together, club indistinctly four-jointed. Thorax with a distinct mesoepinotal impression; epinotal spines acutely attenuate, straight, projected backwards and upwards at about 15°, slightly longer than the declivity ventral to them; from above, nearly three

times as long as the distance between their bases, moderately diverging. Petiole, in profile, with a distinct peduncle, anterior declivity feebly concave dorsally, slightly convex ventrally, dorsal surface of node feebly convex, about one-fourth longer from apex of ventral tooth to postpetiole than high. Postpetiole higher than petiole, about as long as high, ventral surface nearly flat, dorsal surface produced posteriorly in a convex lobe. Gaster elliptical, legs long and slender.

Surface of head coarsely reticulate-vermiculate, longitudinally rugose only for a short distance posterior to the frontal area, clypeus shallowly rugulose except on the posterior margin, frontal area shining, finely punctulate; base of sculpturing densely punctate. Dorsal surface of thorax coarsely reticulate, without a longitudinal trend; sides rugose. Dorsal surface of petiole irregularly vermiculate-reticulate, sides sparsely vermiculate, base of sculpturing punctate. Dorsal surface of postpetiole finely and densely rugose-punctate, sides more sparsely rugose, densely punctate. Gaster shining, ridged at the peduncle, finely reticulate. Antennal scapes finely and densely striate-punctate; legs finely and densely reticulate-punctate.

Pilosity rather sparse and fine, more numerous and oblique on appendages. Antennal club pubescent.

Color dark reddish brown, appendages somewhat lighter.

Described from two workers from Tonglu, Darjiling dist., E. Himalayas, 10,000 feet, 22.IV.10 (C. W. Beebe) in Dr. W. M. Wheeler's collection, with the Indian Museum labels and numbers 8612–19 and 8614–19.

This subspecies differs from the typical *ritae* chiefly in sculpture and color. The head is not sculptured in even ridges, the dorsal surface of the thorax not longitudinally vermiculate and the gaster is finely reticulate instead of smooth. The color is much darker and the cheeks and legs do not contrast conspicuously with the adjacent surfaces. From *r. serica* it differs chiefly in more reticulate sculpturing on the head and thorax, gaster distinctly reticulate, epinotal spines nearer the horizontal and darker coloration of the appendages. It is distinct from *r. formosae* in shorter epinotal spines, in sculpturing and in much darker coloration of the appendages.

Myrmica ritae subsp. serica Wheeler

M. margaritae var. *serica* Wheeler, 1928, Boll. Lab. Zool. R. Ist., Portici, 22: 8–9, ♀.

Worker (type):—Length 5.9 mm.

Head about 0.68 as broad between the eyes as long (with mandibles), occipital margin straight, the angles evenly rounded, eyes a trifle closer to the anterior clypeal than to the occipital margin, clypeal margin with a median rounded notch; frontal carinae low, horizontal, shaped in a subhorizontal ridge; antennal scape very slender, bent evenly at the basal seventh, exceeding the occipital border by about three times its distal diameter, joints 1 and 2 of the funiculus together distinctly shorter than joints 3 to 5 together, club four-jointed. Thorax, in profile, shallowly convex to the distinct and moderately deep mesoepinotal impression; epinotal spines bent near the base, slender, attenuated, projected

backwards and upwards at about 30°, over one-fourth longer than the declivity ventral to them, from above, over three times as long as the distance between their bases, slightly diverging; metasternal spines produced in an acute tooth pointing upwards. Petiole, in profile, with a distinct subcylindrical peduncle, slightly convex dorsally, and a node with feebly convex dorsal surface, anterior declivity evenly concave to the peduncular convexity, about one-half longer from apex of ventral tooth to postpetiole than high. Postpetiole slightly longer than high, ventral surface nearly flat, dorsal surface convex. Gaster ovate. Legs long and slender.

Surface of head sharply and deeply sculptured; of clypeus sharply and irregularly rugose, frontal area sharply triangular, microscopically striate-punctate; between the frontal carinae six more or less continuous rugae, sides reticulate-rugose; base of sculpturing shining, shallowly punctate. Dorsal surface of thorax sharply and deeply vermiculate irregularly, sides deeply rugose. Sides of pedicel irregularly rugose; dorsal surface of petiole interruptedly rugose, of post-petiole rugose, somewhat fused on the posterior margin. Gaster smooth and shining. Antennal scapes densely striate, legs shallowly punctate.

Pilosity moderately abundant, hairs of the body long and acute, shorter on the gaster; appendages with fine, oblique to subappressed hairs. Antennal club and tarsi pubescent.

Color of body dark reddish brown, epinotal spines, apex of gaster and appendages dark yellowish brown.

Female, dealated (undescribed):—Length 6.9 mm.

Similar to the worker. The epinotal spines are fully as long and somewhat curved downwards. The sculpturing is similarly coarse; the median rugosity on the clypeus higher than the others, anterior border of the frontal area confluent with the clypeus and smooth and shining; antero-median triangular area on the scutum of the mesonotum finely striate-punctate, coarse, deep vermiculate rugosities extending posteriorly.

Color as in the type worker, lighter than the workers taken with it.

Type Locality. CHINA: Yunnanfu (F. Silvestri) 1 ⚲.

Other Locality. FORMOSA: Arisan (L. Gressitt) 4 ⚲, 1 ♀.

The Formosan workers are somewhat darker than the type specimen and a little more shining; the antennal scapes are slightly shorter.

This subspecies differs from the typical *M. ritae* chiefly in more irregular sculpturing and in darker coloration; from the subsp. *formosae* it varies chiefly also in sculpturing and darker coloration, especially on the legs.

For the shifting of this ant from a variety of *M. margaritae* to a subspecies of *M. ritae*, see above under *formosae*.

Myrmica everesti Donisthorpe

M. everesti Donisthorpe, 1929, Ann. Mag. Nat. Hist. (10) 4: 445–446, ⚲.

Worker (after Donisthorpe:—"Dark brown, head and gaster except apex almost black, coxae, mandibles, articulations of the legs and antennae, and apex of gaster reddish. Body furnished with sparse, scattered, yellow hairs.

"Head strongly longitudinally striate, temples and occiput reticulated; mandibles longitudinally striate, masticatory margin with terminal tooth long and curved, second tooth shorter but distinct, the rest indistinct; clypeus with anterior border produced and pointed, entirely longitudinally striate; frontal area smooth and shining; scape of antennae reaching beyond posterior margin of head, funiculus with a distinctly 4-jointed club. Thorax strongly reticulate, longitudinally striate at sides; epinotal spines very short, sharply pointed, very slightly curved inwards, very shining between the spines, but distinctly though finely transversely striate. First node of pedicel rugosely punctured above, longitudinally striate at sides, with a distinct tooth or spine projecting forward at its base beneath; second node rugosely longitudinally striate, broader but shorter than first node, rounded at sides, with a very blunt projection at its base beneath. Gaster oval, very shining; sting strong. Long. 4.5–5 mm.

"This species comes near to *M. smythiesi*, Forel, but is darker and slightly more robust; the antennae are shorter and stouter, the spines shorter and more curved. The spines are about the same length as those of *M. tibetana*, Mayr, but are broader at the base and more curved. The whole of the insect is much more rugose than *tibetana*, the space between the spines being smooth in the latter.

"Described from five ♀ ♀ taken by Major R. W. G. Hingston at Jelap La (Tibetan side), at a height of 12,000 ft., on April 1st, 1924 (Everest Expedition). Type and paratypes in the British Museum Collection."

Myrmica specularis Donisthorpe

M. specularis Donisthorpe, 1929, Ann. Mag. Nat. Hist. (10) 4: 446, ♀.

Worker (after Donisthorpe):—"Red-brown, head and gaster black, apices of mandibles, articulations of legs and antennae, base of thorax including the epinotal spines and the space between, the nodes anteriorly and posteriorly reddish; covered with stiff scattered white bristles.

"Head somewhat square, rounded behind, front longitudinally striate with a few cross-striae, temples, cheeks, and occiput rather strongly reticulate; mandibles longitudinally striate, with several transverse striae towards the apex; clypeus convex, rounded in front, both longitudinally and transversely striate; frontal area smooth and shining; scape of antennae evenly curved at base, funiculus with 4-jointed club.

"Thorax strongly reticulate, longitudinally striate at sides; spines long, strong, and sharply pointed, pointing backwards, but slightly curved downwards, space between smooth and shining. First node of pedicel high, with a strong tooth beneath pointing forwards, punctured and somewhat reticulate above; second node shorter and in profile not so high as first node, slightly less punctured, with somewhat deep longitudinal pits. Gaster smooth and very shining. Long. 6–6.5 mm.

"The spines are more divergent than in *M. rugosa*, Mayr, the apex of the clypeus is not pointed, the nodes of the pedicel are broader and not so closely sculptured, and the insect is not so dark in color.

"From *M. ruginodis*, Nyl., the present species differs in its much darker color and more robust form, and in the space between the spines

being smooth.   The head is much more strongly reticulated, the body generally is more coarsely sculptured, and the bristles are stronger, longer, and more numerous.   Described from eight ♀ ♀ taken by Major R. W. G. Hingston in Tibet, Gautsa, at a height of 13,000 ft., on April 5, 1924 (Everest Expedition).   There are also ten specimens in the British Museum Collection taken at Khamba Jong, Sikhim, 15–30. vii. 03, at a height of 15,000–16,000 ft. (Tibet Expedition, 1903), which agree quite well with the above species with the exception of not being quite so dark.

"Type and paratypes in the British Museum Collection."

No species of *Myrmica* appears to have been taken at an elevation higher than the above 15,000–16,000 feet.   *M. ruba khamensis* Ruzsky was taken at 11,400 feet, *M. tibetana furva* Ruzsky at 12,500 feet and *M. kozlovi* Ruzsky at 13,000 feet in Tibet.   In North America *M. brevinodis sulcinodoides* Emery was taken at 13,000 feet in New Mexico and *M. lobicornis fracticornis* Emery at the same elevation in Arizona.

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SUBTROPICAL ENTOMOLOGY, by WALTER EBELING. xii+747 pp., 570 text figures. Lithotype Process Co., San Francisco. 1950. Price, $7.50.

This treatise is the outgrowth of the author's teaching experience in a course called, "Insects Affecting Subtropical Fruit Plants," designed primarily for majors in Subtropical Horticulture, University of California, Los Angeles. The first 17 chapters (350 pages) deal with the principles of applied entomology and cover such subjects as the history of applied entomology, organization and legislation in entomology, morphology, metamorphoses, classification, biological control, insecticides (10 chapters, 150 pages), dispersion equipment, experimental design and evaluation of treatment. The remaining 11 chapters (369 pages) are devoted to specific insects attacking such subtropical crops as citrus, grapes, walnuts, pecans, almonds, figs, olives, avocadoes, and dates, as well as other subtropical fruits of minor importance. Under "Literature Cited" are recorded 1,032 entries. Author and subject indices are included. There are numerous original photographs which show a high degree of skill.

Although the pests discussed are largely endemic to California, and the writing is slanted towards conditions peculiar to the West Coast, the greater part of the information would be highly valuable to all areas of the world where subtropical plants are grown commercially. In addition, approximately the first half of the book, dealing with the principles of economic entomology, would apply to other fields of insect control.

The sections of insecticides and equipment are particularly thorough. Fifty pages alone are devoted to "Spray Oils." There is considerable material not included in other texts of this nature. For example, a chapter is devoted to the various governmental agencies dealing with entomology and the relationships between them. Another chapter (62 pages) discusses citrus pests of foreign countries.

This treatise will no doubt establish a milepost in the science of subtropical entomology. The author should be commended on such an exhaustive, well-done book. It will serve well the needs of students, teachers, and research workers, in fact, any technically trained person who deals with insects of the world's citrus belt.—H. S. TELFORD

FLORIDA ASILIDAE (DIPTERA) WITH DESCRIPTION OF ONE NEW SPECIES

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Stamford, Conn.

There have been many additions to the asilid fauna of Florida since my great friend and mentor, the late C. W. Johnson, for many years Curator of Insects at the Boston Society of Natural History, published the "Diptera of Florida" in 1913 (Bul. Am. Mus. Nat. Hist., vol. 32, Art. III, pages 37-90). In that work, on pages 60 to 62 he listed 52 asilids for the state. In 1929, the late Dr. J. R. Watson, State Entomologist of Florida, and Dr. M. D. Leonard urged me to prepare a work on Florida robber flies. Starting with the material in the Experiment Station at Gainesville and the collection at the U. S. Bureau of Entomology at Orlando, where Mr. W. W. Yothers had obtained a number of interesting records of this family of flies, I was able to amass a considerable amount of data. Later, Mr. Robert Foster, State Bee Inspector, turned over to me the material received from his men, Mr. A. C. Lundin and Mr. John D. Haynie. Through the kindness of Dr. E. S. Thomas, the records of the Ohio State Museum, and through Dr. Josef Knull, those of the Ohio State University were made available. To Col. F. S. Blanton, who gave me records collected by himself and his brother Alton, and to Dr. R. H. Beamer whose collector associates, J. D. Beamer, A. T. and D. E. Hardy, P. B. Lawson, P. W. Oman, W. Benedict, and E. G. Wegenek, who amassed a great many records, the writer is also indebted, while Dr. Josef Bequaert furnished many from the Museum of Comparative Zoology. Dr. J. G. Needham kindly send me records from the Archbold Laboratories, Lake Placid. My own records collected in 1923, 1924, 1928, 1929 and 1935 are included as are those of the late William T. Davis. In 1934, I had access, through the kindness of Dr. Ray Hutson, to the A. J. Cook collection at the State Experiment Station, East Lansing, Michigan, and a number of interesting notes were added from here. To all these as well as to numerous other collectors to whom credit is given in the list, the writer is deeply grateful.

COLLECTOR OR COLLECTION INITIALS

AB	=Alton Blanton	JRW	=J. R. Watson
ATH	=A. T. Hardy	LMJ	=Leonora M. Gloyd
CWJ	=C. W. Johnson	MCZ	=Museum of Comparative Zoology
EAB	=E. A. Back	MDN	=Mary D. Neiswander
DEH	=D. Elmo Hardy	OSM	=Ohio State Museum
EST	=E. S. Thomas	PWO	=P. W. Oman
EGW	=E. G. Wegenek	RD	=Richard Dow
EWB	=Unknown (Gainesville)	RHB	=R. H. Beamer
FSB	=Col. F. S. Blanton	SWB	=Stanley W. Bromley
HH	=Major Harry Hoogstraal	USNM	=U. S. National Museum
JDB	=Jack Beamer	WEG	=W. E. Goslin
JDH	=John D. Haynie	WTD	=William T. Davis

ASILIDS AS HONEY-BEE ENEMIES IN FLORIDA

Florida is one of the few states where robber flies have caused economic losses to bee keepers.   There are more records of asilids causing damage to apiaries by killing and feeding on bees in Florida than in any other state except Texas.   Most of the losses have been due to a very few species, the outstanding bee-killers here being *Mallophora orcina* Wied. and *M. bomboides* Wied. both bumblebee-mimics. Mr. C. W. Johnson with his father maintained an apiary at St. Augustine from 1880–1888 until it was so depleted by robber fly and dragon fly attacks that the bee-moth was able to get in and completely ruin the colonies.   Great swarms of the dragon fly, *Coryphaeschna ingens* Rambur, coursing back and forth close to the hives at dusk, snatched up the late returning workers in great numbers.   During periods of hot sunlight thousands of bees fell prey to two asilids: *Mallophora orcina* Wied., in late spring and summer and *Mallophora bomboides* Wied., in fall and winter.   Other asilids killed bees but were of less importance: *Mallophora nigra* Williston and *Proctacanthus heros* Wied., were rare but fed on the bees near the hives (latter noted as perching on the hives); *Promachus fitchii* O. S. was abundant one season and killed many bees, but then disappeared; the large *Diogmites crudelis* Bromley (*Deromyia* aucct. not Philippi) occurred in long grass near the apiary and caught many bees; others of minor importance were *Proctacanthus brevipennis* Wied., *Deromyia ternata* (now known as *Diogmites neoternatus* Bromley) and *D. bilineata* (now known as *Diogmites esuriens* Bromley).

Since then several similar instances of asilid depredations on bees particularly in the Appalachicola region have been recorded in the bee journals.

Proctacanthus heros Wied., is a large reddish species, rare throughout most of its range in the Southeastern States, but may be locally abundant in areas of reddish-yellow sand.   It is said to suck honeybees while resting on a fence post or even on the hive.   In the A. J. Cook collection at the Michigan State College, East Lansing, Michigan, are specimens from Mt. Dora sent in by a bee keeper on July 26, 1889, with the note that they were caught in the act of feeding on honeybees.   Mr. J. D. Haynie found *P. heros* killing honey-bees in an apiary at O'Brien on October 9, 1940.

There are many records of *Mallophora bomboides* killing bees.   In the fall of 1907, Dr. E. A. Back collected more than a dozen specimens with honey-bee prey at Orlando.   In early October, 1935, Mr. A. C. Lundin found *M. bomboides* killing honey-bees in a bee yard at Clearwater.   I found this species preying extensively on honey bees at Lake Worth in the fall and winter of 1928.   Dr. R. H. Beamer found it killing bees at Lake Placid on July 13, 1948.

Dr. J. Speed Rogers informed me in January 1929 that *Proctacanthus brevipennis* Wied., was abundant at Gainesville during late winter and early spring and thought it killed more honey-bees than any other asilid at least at that time of year.   Mr. John D. Haynie found *brevipennis* killing honey-bees on June 20, 1940 in West Florida.   He also found *Proctacanthus gracilis* Bromley killing honey-bees in a bee yard at Live Oak on August 16, 1940.   In addition, he took *Proctacanthus*
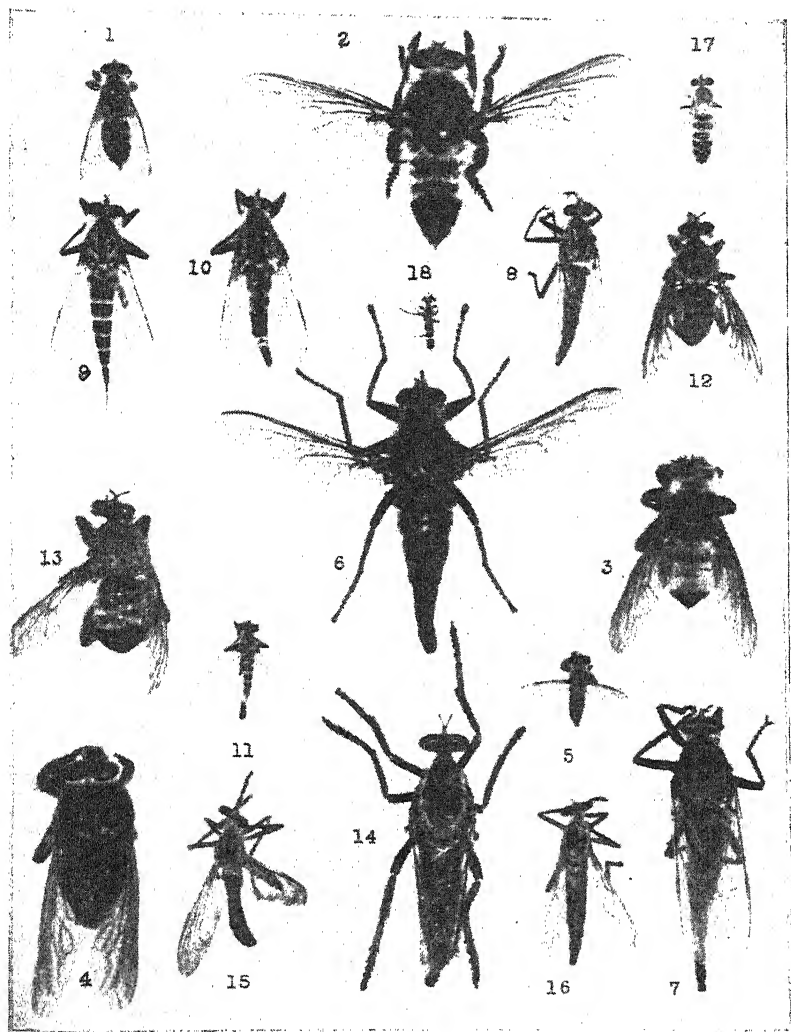
FIG. 1. *Mallophora laphroides*. FIG. 2. *Mallophora bomboides*. FIG. 3. *Mallophora orcina*. FIG. 4. *Mallophora nigra*. FIG. 5. *Mallophora minuta*. FIG. 6. *Proctacanthus heros*. FIG. 7. *Proctacanthus longus*. FIG. 8. *Proctacanthus brevipennis*. FIG. 9. *Erax femoratus*. FIG. 10. *Erax interruptus*. FIG. 11. *Erax tabescens*. FIG. 12. *Laphria saffrana*. FIG. 13. *Bombomima floridensis*. FIG. 14. *Diogmites crudelis*. FIG. 15. *Diogmites neoternatus*. FIG. 16. *Diogmites esuriens*. FIG. 17. *Laphystia litoralis*. FIG. 18. *Stichopogon abdominalis*.

longus Wied., with honey-bee prey at an apiary in Mayo on June 30, 1937; also, *P. nigriventris* Macquart on honey-bees at Live Oak, on August 16, 1940. Another record for *P. longus* was at Orlando in 1923 where a bee-keeper found several eating honey-bees in a cow pasture near the apiary. Mr. A. C. Lundin found *Promachus rufipes* Fabr., killing many honey-bees in an apiary at Bradentown in August, 1936. The late Wm. T. Davis found *Proctacanthus fulviventris* Macquart preying on honey-bees at Ocean Beach, Miami, on August 23, 1913. In 1935, a bee-keeper in Lake Worth saw *Erax femoratus* Macquart sucking bees on a barb-wire fence near the bee-hives. Again Mr. J. D. Haynie found *Diogmites salutans* Bromley and *D. esuriens* Bromley killing honey-bees in apiaries at Live Oak in August 1940. Mr. Davis found *Promachus quadratus* with a honey-bee prey at Lakeland.

TABLE OF FLORIDA BEE-KILLERS

NAME OF ASILID	NUMBER OF HONEY-BEE PREY RECORDS
1. *Mallophora orcina*	1000 plus
2. *Mallophora bomboides*	500 plus
3. *Proctacanthus heros*	50 plus
4. *Promachus fitchii*	50 plus
5. *Diogmites crudelis*	50 plus
6. *Mallophora nigra*	20 plus
7. *Proctacanthus brevipennis*	20 plus
8. *Promachus rufipes*	10 plus
9. *Proctacanthus fulviventris*	10 plus
10. *Proctacanthus gracilis*	10 plus
11. *Diogmites neoternatus*	10 plus
12. *Diogmites esuriens*	10 plus
13. *Diogmites salutans*	10 plus
14. *Protacanthus longus*	6
15. *Erax femoratus*	4
16. *Stenopogon subulatus*	2
17. *Procacanthus nigriventris*	1
18. *Promachus quadratus*	1

I. LEPTOGASTRINAE

1. **Leptogaster (Psilonyx) annulatus** Say, 1823, Jour. Ac. Nat. Sci. Phila., 3:75. Gainesville (JRW). Abundant in the shade of moist, sandy woods.

2. **Leptogaster atridorsalis** Back, 1909, Trans. Am. Ent. Soc. 35:159. Gainesville (JRW).

3. **Leptogaster badius** Loew, 1862, Berl. Ent. Zeit., 6:188, 6. Gainesville (JRW).

4. **Leptogaster brevicornis** Loew, 1872, Berl. Ent. Zeit. 16:62, 23. Gainesville (JRW).

5. **Leptogaster floridensis** Johnson, 1910, Bul. Am. Mus. Nat. Hist. 32:60. "Miami, Nov. 5, 1911 (CWJ). Estero (Van Duzee)."

6. **Leptogaster obscuripennis** Johnson, 1895, Proc. Acad. Nat. Sci. Phila., 1895: 304. "St. Augustine (CWJ); Capron; Tampa, April 8, (Hubbard); Orlando, May 18; Gotha, March (Wheeler); Clearwater, April 30 (Van Duzee)."

7. **Leptogaster pictipes** Loew, 1862, Berl. Ent. Zeitschr. 6: 189, 7. "Biscayne Bay, (Mrs. Slosson)." Key Largo, 7–19–39 (A. T. Hardy). Found in shade in moist woods.

8. **Leptogaster tenuipes** Loew, 1862, Berl. Ent. Zeitschr. 6:192, 19. Hypoluxo, Nov. 1923, feeding on a mosquito, *Aedes* sp., in jungle (SWB).

II. DASYPOGONINAE

9. **Ceraturgus nigripes** Williston, 1866, Trans. Am. Ent. Soc. 13:287. "Florida" (U. S. N. M.). A *Vespa* mimic.

10. **Ceraturgopsis cornutus** Wiedemann, 1828, Auss. Zweif. Ins I, 382, 25. "Ormond, April (Mrs. Slosson)." Mimic of a black and yellow wasp.

11. **Dioctria albius** Walker, 1849, List Dipt. Brit. Mus. II, 301. "Florida" (E. A. Back).

12. **Dioctria brevis** Banks, 1917, Psyche 24:118. Talahassee (JRW).

13. **Dioctria seminole** Bromley, 1924, Occ. P. Boston S. N. H., 5:125. Talahassee, May 2, 1915 (E. S. Spooner), holotype in Cornell Univ. Coll.

14. **Cyrtopogon falto** Walker, 1849, List Dipt. Brit. Mus. II, 355. "Florida (Morrison)."

15. **Dizonias tristis** Walker, 1851, Ins. Saundersiana, Dipt. I, 93. "St. Augustine (CWJ); Georgiana (Whitfield); Enterprise, May 15; Turkey Lake, Orange Co., Aug. 29 (Back); Biscayne Bay (Mrs. Slosson) LaBelle, Apr. 28." Gainesville, June 2, 1917, female, feeding on beetle, *Epicerus formidolosus* (JRW), also 5–17–14 (JRW) and 5–9–23 (J. S. Taylor). Ft. Lauderdale, 7–19–22 (D. M. Bates). Lutz, Pasco Co., 8–29 to 9–1, '46 (M. D. Neiswander) (OSM). Hillsboro Co., Range 18, 8–29–46 (MDM) (OSM). Key Biscayne, 5–22–37 (Richard Dow). A wasp mimic. Feeds on slow-flying beetles. It can inflict a bite which draws blood with its hard, sharp-pointed beak.

16. **Holcocephala abdominalis** Say, 1823, Jour. Acad. Nat. Sci. Phil., 3:50 2. "St. Augustine and Juniper Creek, May 15 (CWJ); Sanford, May 6; Crescent City, April 21 (Van Duzee)." Ocala, Nov. (FSB). Preys on *Culicoides*. Occurs on tips of twigs, low weeds or grass in low country.

17. **Holcocephala calva** Loew, 1872, Berl. Ent. Zeit. 16:73, 35. "Juniper Creek, May 15." Gainesville, 5–13–20, No. 5181 (JRW). Rests on tips of twigs of bushes and small trees.

18. **Holopogon guttula** Wiedeman, 1821, Dipt. Exot., 228, 27. "Jacksonville and Ormond, April (Mrs. Slosson)." Orlando, April 13, '28 (H. T. Fernald). On tips of twigs, low weeds or bushes.

19. **Heteropogon senilis** Bigot, 1878, Ann. Ent. Soc. Fr., (5)8:423. "Florida (Morrison) U. S. N. M." I doubt this record. The type of *senilis* is from California.

20. **Heteropogon rubrifasciatus** Bromley, 1931, Ann. Ent. Soc. Am., 24:2, 432. Lantana, Nov. 4, 1928 (SWB). In scrub country on white sand, alighting on tips of twigs or branches.

21. **Laphystia litoralis** Curran, 1931, Am. Mus. Nov. 487, 16. "St. Augustine, common along the sea-shore, June, July; Capron, April 19; Miami (Laurent)," as *Laphystia sexfasciata*. Daytona Beach, June '20 (No. 5410) (JRW) and 9–19–38 (EST) (OSM). Mimic of a bembicid wasp. Found on sandy sea beaches. (Fig. 17).

22.   **Laphystia ochreifrons** Curran, 1931, Am. Mus. Nov. 487, 16. Appalachicola.   Penascola.   Occurs along sandy areas near the larger streams.

23.   **Stichopogon abdominalis** Back, 1909, Trans. Amer. Ent. Soc., 35: 332.   "Gotha, Mar. (Wheeler); Winter Park and Orlando, Apr., July (E. A. Back)."   Suwanee Springs, 8–2 and 3, '39 (J. D. Beamer). Branford, 8–4–39 (A. T. Hardy and E. G. Wegeneck).   Hudson, 7–23–39 (D. E. Hardy).   (Fig. 18).

24.   **Stichopogon trifasciatus** Say, 1823, Jour. Ac. Nat. Sci. Phil. 3: 51, 3.   Duval Co., 1944 (W. E. G.) (O. S. M.).   Branford, 8–4–39 (A. T. Hardy).   On sand or gravel, alighting on stones or ground. Feeds on flies, small grasshoppers and spiders, including the "Black widow."

25.   **Stenopogon floridensis** Bromley.   Description to appear in Am. Mus. Novitates.   Hillsboro Co., Aug. 28–31, 1946 (M. D. Neiswander).

26.   **Stenopogon subulatus** Wiedemann, 1828, Auss. Zweifl. Ins. 1, 375.   Dunellon, 7–12–39 (J. D. Beamer & D. E. Hardy).   In open sandy woods alighting on bushes or tall grass.

27.   **Diogmites crudelis** Bromley, 1936, Jour. N. Y. Ent. Soc. 44: 230. "St. Augustine (CWJ); Ormond, June (Mrs. Slosson)," as *Deromyia bigoti*.   Childs, 8–6–30 (P. W. Oman).   Pablo Beach, Sept. 5 (WTD). Hilliard, Aug. 19, '30 (R. H. Beamer).   In tall grass.   Feeds on bees and wasps.   Eyes, in life, bright green.   (Fig. 14).

28.   **Diogmites esuriens** Bromley, 1936, Jour. N. Y. Ent. Soc. 44: 230.   Generally distributed throughout the state.   Additions to localities given in original description are: "Florida (Back); St. Augustine (CWJ)" as *Deromyia bilineata*.   Orlando, 7–22–27 (O. C. McBride).   Ft. Myers, 8–1–27 (M. D. Leonard).   Gainesville, Sept. 30, '20 (#5484), Nov. 4, '17 (#2151 and 2153) (JRW).   Daytona Beach, June '20 (#5410).   Vero Beach, 7–23–38 (J. D. Beamer).   Cedar Keys, 8–10–39 (E. G. Wegenek).   Sanford, 8–8–39 (D. E. Hardy). DeLand, 8–8–39 (E. G. Wegenek).   LaBelle, 7–18–39 (A. T. Hardy). Live Oak, 8–16–40 (J. D. Haynie).   Feeds on bees and wasps. (Fig. 16).

29.   **Diogmites misellus** Loew, 1866, Berlin. Ent. Zeit., 10: 22, 39. "Florida U. S. N. M.," as *Deromyia winthemi*.   Gainesville, 8–19–17, on bitterweed (J.R.W.), also 8–9–17 and 8–27–16 (JRW).   Bratt, June (FSB).   Wakullah, 7–10–39 (J. D. Beamer).   Suwannee Springs, 8–2 and 3, '39 (E. G. Wegenek).   Branford, 8–4–39 (A. T. Hardy). Live Oak, 8–16–40 (J. D. Haynie).   Feeds on ants which it deftly picks off grass stems.   Generally distributed throughout state in dry fields.

30.   **Diogmites neoternatus** Bromley, 1931, Ann. Ent. Soc. Amer. 24, 2, 433, as *Deromyia*.   "St. Augustine (CWJ); Ft. Myers, April 25 and Lakeland, Nov. 8 (W. T. Davis)" as *Deromyia ternata*.   Gainesville, 7–4–18 and 8–16–16 (JRW).   Key Biscayne, 5–22–'37 (Richard Dow).   LaBelle, 7–16–39 (R. H. Beamer).   Jacksonville, 6–19–43 (H. Hoogstraal) "on bamboo."   In moist bushy woods or fields, frequently in partial shade.   When disturbed will fly directly through a thicket, rather than around it.   Has been taken at light.   (Fig. 15).

31. **Diogmites platypterus** Loew, 1866, Berl. Ent. Zeit. 10: 20, 36.
Genotype. Gainesville (JRW). In low moist protected areas.
32. **Diogmites properans** Bromley, 1936, Jour. N. Y. Ent. Soc.
44: 232. Lake City (JRW). Gainesville, 9–30–20 (JRW) and 11–4–17.
Daytona Beach, June, 1920. Bratt, July 21, '38 (Alton Blanton).
Leesburg, 8–19–32 (L. M. Gloyd). Waldo, 8–18–30 (R. H. Beamer).
Suwannee Springs, 7–29–30 (R. H. Beamer). Closely related to
salutans, but darker in color.
33. **Diogmites salutans** Bromley, 1936, Jour. N. Y. Ent. Soc.
44: 233. Gainesville, June 23–Oct. 18 (JRW). Bratt, June–Sept.
(Alton Blanton). Lutz, Pasco Co., 9–1–46 (Mary D. Neiswander)
(OSM). Daytona (MCZ). Crescent City (MCZ). Paradise Key,
Dade Co., May 15, '37 (Richard Dow). Live Oak, 8–16–40 (J. D.
Haynie). In tall grass in moist sandy areas. Feeds on bees, wasps,
bugs and occasionally beetles. Eyes, in life, bright green.
34. **Taracticus octopunctatus** Say, 1823, Jour. Acad. Nat. Sci.
Phil. 3: 49, 1. "Florida (Morrison)." Eyes, in life, bright green.
35. **Nicocles pictus** Loew, 1866, Berlin. Ent. Zeit. 10: 17, 30.
"St. Augustine (CWJ)." In open woods, early spring.
36. **Nicocles politus** Say, 1823, Jour. Acad. Nat. Sci. Phil. 3: 52, 5.
"White Spring, Oct. 19 (Townsend)." On tips of weeds in old sandy
fields, in fall.

III. LAPHRIINAE

37. **Cerotainia macrocera** Say, 1823, Jour. Acad. Nat. Sci. Phil.
3: 73, 3. "Lake Worth (Mrs. Slosson)." Ocala, May 17, '39 (D. J.
and J. N. Knull). Alights on tips of leaves and twigs.
38. **Atomosia puella** Wiedemann, 1828, Auss. Zwei. Ins. I, 531, 58.
"Palatka, May 19, (CWJ)." Duval Co., 1944 (W. E. Goslin) (USM).
Preys on *Hippelates* and *Drosophila*. Alights on exposed tree trunks,
posts, stones or buildings, head downward.
39. **Atomosia rufipes** Macquart, 1847, Dipt. Exot. Suppl. 2, 39, 9.
Gainesville (JRW). Duval Co., 1944 (W. E. Goslin) (OSM). Jackson-
ville (R. L. Blickie). On leaves of plants or low shrubs.
40. **Atomosia sayii** Johnson, 1903, Psyche 10: 113. Lutz, Pasco
Co., 8–29–46 (MDN) (OSM). Alights on leaves of shrubs and low
trees.
41. **Pogonosoma melanoptera** Wiedemann, 1828, Auss. Zwei. Ins.
I, 514, 26. "Florida, Williston." On pine logs or tree trunks.
42. **Andrenosoma cruenta** McAtee, 1919, Ohio Jour. Sci. 19: 244,
as *Nusa*. "Florida." L. O. Howard's The Insect Book, Plate 24,
Fig. 15, as *Nusa fulvicauda* (1901).
43. **Andrenosoma fulvicauda** Say, 1823, Jour. Acad. Nat. Sci.
Phil. 3: 531. "Georgiana (Whitfield); Ormond, June (Mrs. Slosson),"
as *Nusa fulvicauda*. Alights on pine and oak logs, stumps, or cord-
wood in sun.
44. **Lampria bicolor** Wiedemann, 1828, Auss. Zwei. Ins. I, 522, 40.
"Ormond (Mrs. Slosson)." On or near oak stumps or logs.
45. **Lampria rubriventris** Macquart, 1834, Suit. à Buffon, I, 284, 19.
Pasco Co., 8–29–46 (MDN) (OSM). Hillsboro Co., 8–31–46 (MDM)
(OSM). In moist fields. Alights on grass stems or blades.

46. **Laphria saffrana** Fabricius, 1805, Syst. Antl. 160, 18. "St. Augustine (CWJ); Sand Point, May 3; Charlotte Harbor, May; Pensacola, April, and Biscayne Bay, Mar. (Mrs. Slosson); Lakeland, May 6 (Davis)." Orlando, Mar. 17, 1908 (EAB), April '24 (SWB). Lake Worth, 3–23–35 (SWB). Lake City, 4–5–15 (JRW). Gainesville. 4–9–23 (Hammar). Duval Co., 3–10–45 (WEG) (OSM) and Mar. 10, '45 (W. E. Goslin) (OSM). Sand Point, May 3, and Archer, Mar. 1882 (U. S. N. M.). Mimic of queen yellow-jacket, *Vespa squamosa*. Feeds on slow-flying beetles and bees, and occurs around pine logs and stumps. (Fig. 12).

47. **Bombomima cinerea** Back, 1904, Can. Ent. 36: 289, as *Dasyllis*. Jacksonville, April, 1935 (SWB). On logs or stumps in cut-over pine woods.

48. **Bombomima flavicollis** Say, 1824, Long. Exp. St. Peter's River, II, app. 37–4, 2. Gainesville (JRW). On foliage near logs, stumps and woodpiles.

49. **Bombomima floridensis** Bromley. Description to appear in American Midland Naturalist. Gainesville (JRW). Gainesville, Alachua Co., April 4, '28 (E. Haggart). "Crescent City, April 24 (Van Duzee)" as *Dasyllis lata*. Mimetic of *Bombus americanorum*. (Fig. 13).

50. **Bombomima grossa** Fabricius, 1775, Syst. Ent. 791, 1. Jacksonville. Around oak logs, stumps and woodpiles in sunlight.

51. **Bombomima lata** Macquart, 1849, Dipt. Exot. Suppl. 4, 75. "Crescent City, April 24 (Van Duzee)." "Tampa, March (Mrs. Slosson)" as *Dasyllis grossa*.

52. **Bombomima pulchella** Bromley. Description to appear in American Midland Naturalist. Gunntown, March (P. Laurent).

53. **Bombomima thoracica** Fabricius, 1805, Syst. Antl. 158, 10. Talahassee (JRW). Marianna (JRW). Bumble-bee mimic.

54. **Bombomima virginica** Banks, 1917, Bul. Brook. Ent. Soc. 12: 53, as *Dasyllis*. Jacksonville, April, 1935 (SWB). Greenville, May 2, 1935. On logs or stumps in cut-over pine woods.

55. **Orthogonis stygia** Bromley, 1931, Ann. Ent. Soc. Amer. 24: 453. Gainesville (JRW) as *Pogonosoma melanoptera*.

IV. ASILINAE

56. **Mallophora bomboides** Wiedemann, 1821, Dipt. Exot. 203, 37. THE FLORIDA BEE KILLER. "St. Augustine (CWJ); Ormond, June (Mrs. Slosson); Miami, Nov. 5." Gainesville, 9–21 to 10–15 (JRW, E. W. B. and H. L. Dozier). Sparkman, 9–21–28 (#7035) (J. W. Harris), a female feeding on a *Xylocopa virginica*. Palm Beach, Dec. 21, '40 (Wm. Procter). Lake Worth, Jan. 24, 1924 (SWB). Hypoluxo, Nov. 8, '28 to Jan. 15, '29 (SWB). Orlando (F. L. Van Dauber). Lake Placid, 7–13–48 (R. H. Beamer). Clearwater, early Oct. '35 (A. C. Lundin) feeding on honey-bee. Lake Worth, Nov. 1928, feeding on female *Bombus americanorum*, *Bombus impatiens*, *Vespa squamosa* and *Polistes bellicosus*. (Fig. 2).

57. **Mallophora clausicella** Macquart, 1849, Dipt. Exot. Suppl. 4, 79, 27. Jacksonville (SWB).

58. **Mallophora laphroides** Wiedemann, 1828, Auss. Zwei. Ins. I, 483, 88. "St. Augustine (F. H. Genung); St. Petersburg, April 28, and

Clearwater, May 1 (Van Duzee); Lakeland, May 7." In Georgia and S. Carolina noted as feeding on small bugs, beetles, wasps and bees, including the honey-bee. (Fig. 1).

59. **Mallophora minuta** Macquart, 1834, Suit. à Buffon I, 302, 5. Lake Worth, Nov. 1928 (SWB). Winter Park, May 26, '37 (Richard Dow). Sanford, Aug. 8, '39 (R. H. Beamer). LaBelle, 7–16–39 (D. E. Hardy). Hudson, 7–13–39 (J. D. Beamer). Largo, Aug. 21, '31 (Bradley & Knorr). The smallest species of the genus. (Fig. 5).

60. **Mallophora nigra** Williston, 1885, Trans. Am. Ent. Soc. 12:58. THE BLACK BEE KILLER. "St. Augustine (CWJ)." Duval Co., Nov. '44 (WEG) (OSM). Lake Placid, 7–13–48 (E. L. Todd and R. H. Beamer). Preys on honeybees and bumblebees. (Fig. 4).

61. **Mallophora orcina** Wiedemann, 1828, Auss. Zwei. Ins. 1, 477, 79. THE SOUTHERN BEE-KILLER. "St. Augustine, May 20, and Palatka, May 19 (CWJ); Crescent City (Hubbard)." Gainesville, 8–15–17 (JRW), Lake City, July, 1895. Royal Palm Park, July, 1947 (A. Klots) and Key Largo, July, 1948 (A. Klots), both American Museum of Natural History. Mimic of worker *Bombus americanorum*. Feeds on bees and wasps. Lives in swales, edges of cultivated fields, pastures, and woods, alighting on weed stalks and low bushes. Frequents apiaries and bee yards. Flies with a soft deep buzz. The illusion of a bumblebee in flight vanishes when the fly comes to rest. (Fig. 3).

62. **Mallophora rex** Bromley, 1925, Psyche, 3:192. "Florida," paratype. Mimic of *Bombus americanorum* queen.

63. **Promachus bastardi** Macquart, 1838, Dipt. Exot. I, 2, 104, 30. THE FALSE NEBRASKA BEE-KILLER. "Clearwater, April (Van Duzee); Lakeland, May 6 (Davis.)" Orlando, April 6, 1920 (R. H. Cotton). Orlando, July 21, 1925 (O. C. McBride). Gainesville, 7–7–18 (#2953) (JRW).

64. **Promachus fitchii** Osten Sacken, 1878, Cat. Dipt. N. A., Ed. 2, 234, 121. THE NEBRASKA BEE-KILLER. "St. Augustine (CWJ)." Florida (Hine).

65. **Promachus quadratus** Wiedemann, 1821, Dipt. Exot. 201, 34. Lakeland (WTD). Coconut Grove, June 6, '32. Larger than *bastardii* and with more white hairs on the body and legs. I have a specimen 41 mm. in length.

66. **Promachus rufipes** Fabricius, 1775, Syst. Ent. 794, 16. THE BEE PANTHER. Gainesville, 7–23–16 and 7–2–18 (#965 and #2807) (JRW). Paradise Key (MCZ). Bradentown, Manatee Co., Aug. 1936 (a male and female, each with honey-bee prey collected in apiary).

67. **Neoitamus (Aslius) flavofemoratus** Hine, 1909, Ann. Ent. Soc. Amer. 2:153, as *Asilus*. Gainesville (JRW).

68. **Proctacanthus brevipennis** Wiedemann, 1828, Auss. Zwei. Ins. 1, 431, 10. "St. Augustine (CWJ); Ormond, Charlotte Harbor and Pensacola (Mrs. Slosson); Miami, April 4 (Laurent); Key West, June 7; Clearwater, May 1 (Van Duzee); Lakeland, Mar. 28, and Ft. Myers, April 2; Marco, April 18 (Davis)" Gainesville, 3–31 to 5–24 (JRW). Alachua Co., 4–27–23 (JRW). Haines City, Mar. 20, '35 (SWB). Lake Worth, Mar. 23, '35 (SWB). Archbold Laboratories, Lake Placid, April, May (Dr. Needham). Monticello, Mar. 30, '35 (G. Fairchild). Palatka (F. A. Eddy). Dunellon, 7–12–39 (R. H. Beamer).

West Florida, June 1, '40 (J. D. Haynie), feeding on honey-bee. Suwanee, Mar. 2nd and 3, '39 (D. E. Hardy). Archbold Biological Station, Lake Placid, April 15, '45 and Jan. 20, '47 (J. G. Needham). Edgewater, Mar. 15, '39 (C. A. Frost). Miami (A. E. Wight). Altamount (F. A. Eddy). (Fig. 8). Common in open sunny flat woods on sand. Preys on bees, beetles, bugs, flies, and dragon flies, and has been taken as prey of the Dragon flies, *Epiaeschna heros* and *Coryphaeschna ingens* by Dr. T. H. Hubbell.

69. **Proctacanthus fulviventris** Macquart, 1849, Dipt. Exot. Suppl. 4, 88, 12. "Georgiana; St. Petersburg, April 28 (Van Duzee); Ft. Myers, April 24 (Davis)." Lake Worth, Nov. 4, 1928 (SWB). Hobe Sound, 7–21–39 (R. H. Beamer), preying on wasp, *Polistes bellicosus*. In scrub and white sand, alighting on or close to the ground.

70. **Protacanthus gracilis** Bromley, 1928, Psyche, 35: 1, 15. Hillsboro, 8–28 to 31, '46 (MDN) (OSM). Wakullah, July 10, '39 (J. D. Beamer), Sanford, 8–8–39 (R. H. Beamer). Live Oak, 8–16–40 (J. D. Haynie).

71. **Proctacanthus heros** Wiedemann, 1828, Auss. Zweifl. Ins. I, 427, 4. THE GIANT BEE-KILLER. "St. Augustine (CWJ); Georgiana (Whitfield)." Florida (Hine). O'Brien, Oct. 9, '40 (J. D. Haynie) preying on honey-bee in apiary. Branford, 8–4–39 (A. T. Hardy), LaBelle, 7–16–39 (A. J. Hardy and R. H. Beamer). Gainesville (JRW). Fernandina (USNM). This large reddish-brown species is the largest asilid in the U. S. east of the Mississippi, reaching a length of 45 mm. Has been taken sucking honey-bee prey while resting on a hive or nearby post. Known also to prey on bumble-bees, large tabanids (as *T. atratus*), dung beetles (*Phanaeus*) and burying beetles (*Necrophorus carolinus*), the Indian cetonia, and cicadas. Found in reddish-yellow sand country, alighting on logs, stumps, snags and fences in *Pinus taeda* areas. It is not wary but trusts its protective coloration which blends with the dead pine bark where it rests. When sufficiently disturbed it flies off with a loud zooming buzz. (Fig. 6).

72. **Proctacanthus longus** Wiedemann, 1821, Dipt. Exot. 183, 1. "Georgiana (U.S.N.M.)" as *P. philadelphicus*. Plymouth, Aug. 11, 1920 (W. W. Yothers). Lake City, June 12, 1889, also 6–12–99 (#313). Mandarren, Aug. 22, 1922 (Bratley). Hillsboro Co., Range 18, Aug. 24, '46 (MDN) (OSM). Panama City, 5–13–48 (Beach and dunes) (F. Warner and W. Nutting). Preys on grasshoppers in sandy fields and pastures. Has a peculiar undulating flight, alternately gliding and hovering, like a gomphine dragon fly. Mayo, 6–30–37 (J. D. Haynie) (in apiary, preying on honey-bee). Branford, 8–4–39 (D. E. Hardy and A. T. Hardy), Suwanee Springs, 8–2 and 3, '39 (E. G. Wegenek). Hillsboro Co., Aug. 28–31, '46 (MDN). Monticello, July 30, 35 (G. Fairchild). (Fig. 7).

73. **Proctacanthus milbertii** Macquart, 1838, Dipt. Exot. I, 2, 124, 8. THE BOO-HOO FLY or MISSOURI BEE-KILLER. Bratt, Sept. 1 and Sept. 14, '33 (FSB). Feeds on Lepidoptera and Orthoptera. In sandy fields and pastures in the northwestern portion of the state, alighting on or near the ground.

74. **Proctacanthus nigriventris** Macquart, 1838, Dipt. Exot. I, 2, 124, 9. Dayton (MCZ). Live Oak, 8–16–40 (J. D. Haynie). In scrub on white sand, alighting in thickets.

75. **Proctacanthus rufus** Williston, 1885. Trans. Am. Ent. Soc. 12:74. THE RED BOO-HOO FLY. Gainesville (JRW). Preys on aculeate Hymenoptera. Found on sand outwashes along streams.

76. **Erax aestuans** Linnaeus, 1767, Syst. Nat. Ed. XII, II, 100, 75. THE COMMON FLY-HAWK. "Jacksonville, and Lake Worth, March (Mrs. Slosson); St. Petersburg, April 28; Clearwater, April 30; Tampa, May 2 (Van Duzee)." Florida (Hine). Lake City (JRW). Duval Co., 1944 (WEG) (OSM). Alights on bushes, fences, buildings and even on live-stock and man himself. Feeds on flies and mosquitoes, small moths, bugs and leafhoppers.

77. **Erax apicalis** Wiedemann, 1821, Dipt. Exot. 191, 16. Plymouth, Aug. 11, '20 (W. W. Yothers). Gainesville, 8-26-17 (H. L. Dozier) and 7-7-18 (JRW). Gainesville (8 mi. NW), 9-21-38 (EST) (OSM). Daytona (MCZ). In low bushes or weeds in sandy fields and pastures.

78. **Erax barbatus** Fabricius, 1805, Syst. Antl. 169, 22. THE SAND FLY-HAWK. "St. Augustine (CWJ); Lake Worth, on white sand of open beach (Mrs. Slosson)," as *E. albibarbis*. Bratt, May-July. Gainesville, 4-10-23 (JRW). Daytona Beach, 9-19-38 (EST) (OSM). Lake Worth, Mar. 23, '35 (SWB). Hollywood, 3-2-39 (W. Benedict). Preys on flies, mosquitoes and other small insects, alighting on sand.

79. **Erax femoratus** Macquart, 1838, Dipt. Exot. I, 2, 115, 20. "St. Augustine (CWJ); Clearwater, April (Van Duzee). Bratt, June-August (FSB). Lake Worth, Dec. '23 (SWB). Lantana, Mar. 23, '35 (SWB). Lake City (JRW). Duval Co., '44 (WEG) (OSM). Crescent City (MCZ). Lake Worth, 3-23-35 (SWB). Coconut Grove, 3-31-28 (MCZ). The largest *Erax* east of the Mississippi. Alights on tree trunks or fences. When disturbed it may fly around a tree trunk alighting a few feet further up on the opposite side of the same tree. (Fig. 9).

80. **Erax interruptus** Macquart, 1834, Suit. à Buffon, I, 310, 29. THE SNOREY-JOE FLY or PATHFINDER FLY. "St. Augustine, May 20 and Volusia, May 11-14 (CWJ); Biscayne Bay, March (Mrs. Slosson). Everglade, April 6; Marco, April 17 and labelled May 7 (Davis)." Orlando, 6-10 and 7-25, '26 (O. C. McBride). LaBelle, 7-16-39 (R. H. Beamer and D. E. Hardy). U. S. Naval Hospital grounds, Pensacola, 7-22-43 (F. F. Bibby). Bratt, May-Sept. (FSB). Gainesville, May 21 to Oct. 9 (JRW and H. L. Dozier). Key Largo, 7-16-39 (J. D. Beamer). Hudson, 7-18-39 (D. E. Hardy). Lake Placid, 8-11-45 (J. G. Needham). Paradise Key, Dade Co., May 16, '37 (Richard Dow). Lake City (JRW), Lutz, Pasco Co., 9-1-46 (MDN) (OSM). Lake Placid, April 13, '45 (J. G. Needham) (male with *Sarcophaga* prey). Coconut Grove, 6-27-34 (GBF) male with large *Papilio* prey. Paradise Key, 3-25-35 (SWB). Lake Placid, Mar.-June (J. G. Needham). Alights on ground in paths or roads in fields, pastures or farm yards. Preys on Lepidoptera, Diptera, Orthoptera, and Odonata, frequently larger than itself. (Fig. 10).

81. **Erax rufibarbis** Macquart, 1838, Dipt. Exot. I, 2, 116-22. THE FIELD FLY HAWK. Bratt, Oct. (FSB). Gainesville, Nov. '17 (JRW). Preys on Diptera, small Hymenoptera and Lepidoptera in old fields and pastures.

82. **Erax slossonae** Hine, 1919, Ann. Ent. Soc. Amer. 12:121. "Florida" (Hine). Jacksonville.

83. **Erax stylatus** Fabricius, 1775, Syst. Ent. 795, 19. "Florida" (Hine).

84. **Erax tabescens** Banks, 1919, Ann. Ent. Soc. Am. 12:126. "Florida" (Hine). Gainesville, 4–18–13, 5–28–18, 5–30–16 (JRW). Hillsboro Co., 8–29 to 31, '46 (MSN) (OSM). Hudson, 7–13–39 (J. D. Beamer and A. T. Hardy). LaBelle, 7–16–39 (R. H. Beamer & P. B. Lawson). DeLand, 8–28–39 (E. G. Wegenek). Quincy, July 19, '39 (D. E. Hardy). Branford, 8–4–39 (R. H. Beamer and D. E. Hardy). Sanford, 8–8–39 (R. H. Beamer and D. E. Hardy). Dunellon, 7–22–39 (D. E. Hardy). Hillsboro Co., Aug. 28–31, '46 (MDN). Live Oak, 8–16–40 (J. D. Haynie). Largo, 8–22 to 29, '31 (Bradley and Knorr). (Fig. 11).

85. **Ommatius tibialis** Say, 1823, Jour. Acad. Nat. Sci. Phil. 3:49. "St. Augustine, May 21, and Georgetown, May 19 (CWJ); Georgiana, July 15 (Whitfield); Biscayne Bay (Mrs. Slosson); Sanford, May 7 (Van Duzee)," as *O. marginellus*. Lake City, 5–20–1892, and 189? (PHR). LaBelle, 7–16–39 (R. H. Beamer). Paradise Key, Dade Co., May 16, '37 (Richard Dow).

86. **Ommatius gemma** Brimley, 1928, Jour. E. Mitchell Sci. Soc. 43:205. Gainesville (JRW).

87. **Asilus blantoni** Bromley, 1940, Bull. Brook. Ent. Soc. 35:19. Bratt, April 1–11, 1933 (A. Blanton).

88. **Asilus erythrocnemius** Hine, 1909, Ann. Ent. Soc. Amer. 2:163. "Punta Gorda, Nov 16 (Davis)." Preys on Lepidoptera and small grasshoppers.

89. **Asilus floridensis** Bromley, 1940, Bull. Brook. Ent. Soc. 35:19. Ocala, Nov. 5, 1932 (FSB). Gainesville, 9–9 to 10–30 (H. L. Dozier and JRW) as *A. prairiensis*.

90. **Asilus frosti,** new species

Total length, 12–14 mm. A small grayish-brown pollinose species with entirely black femora, the underside of the front femora with long fine pile (not in rows) as in *snowii* Hine, the tibiae mostly red, three or four spines on the front side of the hind tibiae, the arista as long as antennal segment no. 3, the genitalia shining black, the ovipositor with the terminal lamella not wedged in as in *lecythus* Walker, but free.

Male.—Occipitals, verticals, antennals and upper mystacal bristles, black. Beard and lower hairs of mystax pale straw. Mesonotal hairs and bristles black. Pleura grayish-white pruinose. Pleurals and coxals pale. Wings with cell centers along posterior margin and tip pale brown, as in *snowii* Hine. Halteres pale. Legs with black bristles and pale hairs. Femora entirely black, tibiae and tarsi red with black tips. Genitalia shining black, similar in form to *A. virginicus* Banks.

Female.—Similar.

This species is readily distinguished from *snowii*, *prairiensis*, *floridensis* and *erythocnemius* by the entirely shining-black femora.

Holotype, male, Edgewater, March 16, 1939 (C. A. Frost). *Allotype*, female, Edgewater, March 15, 1939 (C. A. Frost). *Paratopotype*, male, Edgewater, March 17, 1939 (C. A. Frost) with a small tachinid

as prey. *Paratypes,* one male, one female, St. Stephens, South Carolina, May 24, 1934 (O. L. Cartwright).

Named in honor of Mr. C. A. Frost, noted Coleopterist of Framingham, Massachusetts. Types in S. W. Bromley collection.

91. **Asilus gracilis** Wiedmann, 1828, Auss. Zwei. Ins. I, 445. "St. Augustine, May 21; Palatka, May 19 (CWJ); Georgiana, July 15 (Whitfield); Sanford, May 7; Clearwater, April 30; St. Petersburg, April 29; Estero (Van Duzee); Ft. Myers, April 25." Gainesville, 8–26–17 and 9–16–17 (#1772 and #1926) (H. L. Dozier). Duval Co., '44 (WEG) (OSM) and Nov. '44 (W. E. Goslin). Suwannee Springs, 8–2 and 3, '39 (R. H. Beamer). Elfers, July 14, '39 (D. E. Hardy). Branford, 8–4–39 (R. H. Beamer). Found in moist woods near streams or ponds.

92. **Asilus lecythus** Walker, 1849, List. Dipt. Brit. Mus. II, 451. Bratt, April, 1933 (Alton Blanton).

93. **Asilus notatus** Wiedemann, 1828, Auss. Zweif. Ins. I, 451, 40. Jacksonville (JRW). Feeds on flies and small moths.

94. **Asilus maneei** Hine, 1909, Ann. Ent. Soc. Amer. 2:158. Gainesville (JRW). Alights on trunks of oak and pine trees.

95. **Asilus novae-scotiae** Macquart, 1847, Dipt. Exot. Suppl. 2, 46, 62. "Charlotte Harbor (Mrs. Slosson)". Feeds on flies and small moths.

96. **Asilus snowii** Hine, 1909, Ann. Ent. Soc. Amer. 2:160. "Florida (Mrs. Slosson)." Bratt, April (FSB).

INSECT ENEMIES OF EASTERN FORESTS, by F. C. Craighead and others. U. S. D. A. Misc. Pub. 657. ii+679 pages, 197 figures. Price. $2.50.

This important work, a companion volume to Keen's "Insect Enemies of Western Forests" (U. S. D. A. Misc. Pub. 273, 1938, slightly revised 1939), should prove invaluable to forest entomologist and foresters working, particularly, in the area east of the Rockies. We hope that the edition will be large enough to meet the demands until such a time that the work can be reprinted or revised.

This work deals with the identification, biology, life histories, natural enemies, and control of insects of importance in forests roughly east of the 100th meridian. In its general plan it is similar to Keen's work, but it covers a broader, in fact, perhaps too broad, a scope. For example, many Diptera of medical and veterinary importance are included; one might justify inclusion of the Simuliidae on the basis of their annoyance to forest workers, but the inclusion of cattle grubs and of the screwworm seems far-fetched. It would be much more justifiable to include those important pollinizers, the wild bees, but these are omitted except for a brief mention of one leafcutter and one carpenter bee. This inconsistency of treatment results from the fact that sixteen other authors have collaborated with Dr. Craighead in the preparation of the work, but the inconsistency can well be forgiven in light of the more authoritative treatment that results from such an arrangement.

In spite of the very careful screening for errors that U. S. D. A. manuscripts receive, an occasional one will slip in. *"Lambdina"* on page 434, line 31, (but of course not elsewhere in the text) should obviously be *"Ellopia."* The omission of any reference to the important paper by Beal and Massey (1945, Duke Univ. School of Forestry Bul. 10) on the bark beetles of North Carolina is easily explained by the fact that M. W. Blackman, author of the section on the Scolytidae, died before the Beal and Massey work appeared. But any criticism of the work must be trivial; it is an excellent, well-prepared, well illustrated, well-printed volume.

M. T. J.

NEW NORTH AMERICAN TABANIDAE (DIPTERA)

III. Notes on Tabanus molestus and Related Horseflies with a Prominent Single Row of Triangles on the Abdomen.

CORNELIUS B. PHILIP

Hamilton, Montana

Stone (1938), in his monograph of the Nearctic species, has provided the most recent improvement in understanding of *Tababus s. str.* with a single row of pale triangles on the abdomen. Certain of these have shown most confusing variations and still are difficult in some cases to identify. The present paper aims to supplement his able treatment and provide certain new information.

Species such as *aar*, *giganteus*, *imitans*, *recedens*, *johnsoni*, *actaeon*, and *catenatus*, either with reduced or rather indistinct triangles or otherwise divergent, have not been included here. Most of the species agree in having females with two green eye bands on a purple ground; the eyes of a few are uniformly blackish without bands. In many of the species cell R_5 of the wing is narrowed to varying degrees and even closed, either aberrantly, or invariably so in *petiolatus*. The obvious relationship of the latter species to others of the *melanocerus-molestus* complex precludes application here of the name *Bellardia* End. even as a subgenus as discussed in previous papers.

The species are most elaborated in the southeastern United States, and doubtless other undescribed species will turn up as collecting continues, particularly in the early spring and in coastal areas. The writer recognizes the danger, however, with inadequate series, of describing "specimens, not species" among these variants.

COMMENTS ON SPECIES

Tabanus trimaculatus Pal.

One female has turned up with an aberrant, perfect "half triangle" on the left middorsal side of tergite 2, sharply delimited at the median, longitudinal line. The unbanded eyes of *T. superjumentarius*, and more reduced area of enlarged facets in the males, show the two to be more superficially related than might be supposed from their otherwise similar appearance.

Tabanus moderator Stone

Occasional females are seen with the triangle on tergite 2 almost as large as that on tergite 3; such specimens might be keyed to *coarctatus*, but their whitish mid and hind tibiae and pale-haired scutellums will immediately distinguish *moderator*. This triangle in the only known male (Philip, 1941) is obscured by the rather wide, pale hind margin of tergite 2.

Tabanus molestus Say

This species is not uncommon in the southeastern states and, as Stone has observed, shows melanistic variations throughout its range.

Some intergradation occurs, and this caused Stone to decide against separating the dark form. However, most variants fall readily into either the typical or dark form and the writer feels a systematic name for the variant is justified though reluctantly he gives it subspecific rank only because of the Rules. Say's original description is too meager to determine which form he had so that the paler form recognized as typical heretofore is adhered to. The males show more melanistic tendencies than the females.

Tabanus molestus mixis n. subsp.

This is the dark form in which the pile on the under parts of the body and appendages is brown to black, excepting the rather narrow, pallid sternal incisures.

Holotype ♀, 18 mm. Eyes (relaxed) with two narrow, green, parallel stripes on a purple ground. Front 1:4.5, golden-yellow pollinose with a gray, hairless spot above the median callus, short brown pile at the vertex; callosity orange, taller than wide, not quite touching the eye margins along the sides, the upper angles rounded to meet the orange median callus which expands into an elongate ovoid callus, two-thirds the height of the frons. Subcallus deep-yellow pollinose. Face yellowish-brown pilose and pollinose. Antennae brown, the pedicel and base of the plate more reddish. Palpi reddish with brown hair, dense plumose on the first segment, appressed on the second, about four-fifths the length of the proboscis.

Disc of thorax and pallid scutellum as in the typical form, a deep brown prescutellar hair tuft. Pleura and legs concolorous, deep reddish-brown, the vestiture, including that on fore coxae and hind-tibial fringe, deep brown to black, a few sparse pale hairs intermixed on both sides of the hind knee joint. Anterior tibiae not paler basally. Wings with basal veins to the cross veins and furcation more heavily yellow margined, the clouds more pronounced than in the typical pallid form, alular tufts brown.

Dorsal abdominal pale triangles and pallid incisures markedly reduced, the former less half-moon shaped, more equilateral and angular. Venter dark brown, the pale pollinose and pilose hind margins less than one-third the depth of the tergites.

Athens, Georgia, 11 May 1938, J. C. Anderson. In the collection of the author, through courtesy of Dr. H. O. Lund.

Allotype ♂, 18.5 mm. Dark, smoky brown like the ♀ and easily associated. Eyes bare, demarcation of upper area of facets sharp, a little below the mid-line and contiguous with the hind margin above, but the facets only moderately enlarged and slightly paler than the lower area. Occipital tubercle gray pollinose and pilose behind, raised a little above the upper eye level. Second palpal segments about twice as long as thick, ending in a blunt nipple, dark brown with dark pile. Thorax dark brown, gray pollinose anteriorly not extending into gray lines seen in the ♀, the pale pollinose and pilose scutellum even more prominently contrasting than in the ♀. No pale hair tufts on pleurae or alulae. Abdomen acuminate, the only pale hairs forming narrow, tergal and sternal fringes on segments 3, 4, and 5, and sternite 2, expanding into contrasting pale triangles on tergites 3 to 5, but no evidence of any on tergite 2.

State College, Miss., 19 May 1937, D. C. Scott. In the collection of the author, through courtesy of Ross E. Hutchins.

Three other males seen from Mississippi and Tennessee have the dark thoracic vestiture, but the abdominal triangles and incisures above and below are more expansive, giving the venter on sternites 2 to 4 a predominately grayish appearance, plus a gray hind margin on tergite 2. Gray hairs are evident on the bases of the hind tibiae, not evident in the allotype.   These appear intermediate with the typical form of *molestus*.

Paratypes: ♂, Corbin, Ky., 29 May 1939, R. M. Goslin; ♂, 3 ♀, Maryville, Blount Co., Tenn., June 3–6, 1943, Robt. M. Goslin; ♀, Great Smokies National Park, Tenn., Caids Cave, low alt., 1 July 1939, John S. Thomas; 2 ♀, Quantico, Va., 5 and 24 June 1919, Carl D. Duncan; ♂, ♀, Athens, Ga., 16 May 42, C. H. Fitzgerald and 18 May 48, H. O. Lund; ♀, Wilks Co., Ga., 20 July 47, A. J. Rollins; ♀, DeKalb Co., Ga., 15 May 42, Ed Kelley; 2 ♀, Mimsville, Ga., 11 and 24 July 1907; ♂, Kennesaw Mt., Ga., "6–8–28," P. W. Fattig; ♀, Clarke Co., Ga., 27 May 1939, T. G. Fox; ♂, Stone Mt., Ga., 17 June 1917; ♀, same, 1 June 1937; 2 ♀, Liberty Co., Fla., 2 June 1924, T H Hubbell; 2 ♀, State College, Miss., 11 May 1937, Nelson Burch, and 2 August 1939, R. G. Martin; ♀, Estes, Miss., 8 August 1936, J. G. Humphries. In the United States National Museum, Museum of Comparative Zoology, Ohio State Museum, University of Georgia, University of Kansas, University of Michigan, Mississippi State College, L. L. Pechuman and the author.   The females are in close agreement with the holotype, though the frontal callosities and the antennae are usually darker.

Compared with females of typical *molestus* from Pennsylvania, Georgia, Florida, Mississippi, and Louisiana. All these have the characteristic whitish hair on the underside of the body, cheeks, basal palpal segments, alular tufts, coxae, intermixed on the femora, bases of the tibiae including over three-fourths of the hind-tibial fringe, and the venter predominantly or entirely white haired.   In these, the pale triangles on tergites 3, 4, and 5 are broad, half-moon shaped, and the incisures more broadly pale, especially laterally.

Intergrades in one or more of those characters may occur, as Stone (1938) has pointed out, and structural differences are not apparent to separate the dark from the typical form.   Nevertheless, few specimens are so intermediate as to be unassignable.   Five females from Florida to Louisiana, otherwise readily associated with *mixis* by their reduced triangles and dark vestiture black hind-tibial fringes, have scattering pale hairs on the bases of the hind tibiae, and smoky yellow hair tufts on the alulae, below the wing bases, and cheeks.   In these, the venters are still predominantly dark, but the anterior two pairs of tibiae show some pale hairs basally.   In two specimens from Georgia and Kentucky readily associated with the typical form by the broad, rounded triangles, and whitish ventral vestiture including the hind-tibial fringes basally, the fore coxae have blackish hairs on the distal half, and the dark and light areas on the venter are about equally divided.

It is impossible to tell whether Say's original description applies to either of these forms, though descriptions since the time of Wiedemann and Osten Sacken apply to the pallid form, as does a specimen in series

compared by Mr. Oldroyd with the type of Bigot's *Atylotus tenessensis* at the British Museum.

Tabanus nigripes Wied.

As pointed out elsewhere (Philip, 1950a), comparison with the type of two males of *T. coffeatus* Macq. and authors has removed the doubt of conspecificity. Both compared males had bare, protruding frontal triangles, one unworn well-preserved specimen had hardly a trace of median triangles, the other had very plain ones; the type in Copenhagen Museum was declared by Dr. Tuxen to be between the two in pattern, a little larger than either, but also to have the same head characters. *T. nigripes* is the prior name.

Tabanus sulcifrons Macq.

Stone's (1938) decision to combine all names in this complex except *T. abdominalis* seems the only logical course as long as only morphological data are available. Nevertheless, the continued lack of males of the latter and the variability in characters to a greater extent than in most accepted species seem to justify Osten Sacken's suspicion that this is composite. Though the triangles are usually about equilateral and broad, a few darker specimens have them very narrow and almost crossing the tergites to form a broken, narrow line. More rearings of this common species are needed to determine the extent of variability.

Tabanus yulenus n. sp.

This is a medium-sized, yellowish-tan fly of robust build with hyaline wings including the costal cells, cell R_5 narrowed at the margin, no spur or clouds on cross veins, subepaulets hairy, and a middorsal row of rather large pale triangles on the abdomen; the fore tibiae bicolored, palpi slender.

Holotype ♂, 15.5 mm. Head large, eyes bare, area of enlarged facets well marked though not extensive, occupying the upper half, but margined behind with a wide band of smaller facets to the vertex and "rolled" over the hind margin, no traces of eye banding in the lower portion on relaxing, the upper area gray with a short, brown, central transverse dash, occipital tubercle very small and sunken; frontal triangle dull, tan pollinose; face and cheeks whitish pilose and pollinose; antennae with first two segments and base of the plate yellow, remainder and all hairs brown, scape not noticeably enlarged, the plate about twice as long as wide, excision marked, the dorsal tooth rectangulate, (fig. 1B, Part II, 1950b); palpi slender yellow with creamy hairs, the joints subequal, the terminal joint twice as long as thick, slightly enlarged distad of the middle, terminating bluntly.

Thorax and scutellum brown, creamy pollinose, with sparse yellowish appressed and brown upright hairs, with indistinct grayish lines anteriorly, pleural hairs creamy with a few brown intermixed. Fore coxae whitish pilose and pollinose, fore femora chocolate brown with brown and yellow hairs intermixed, fore tibiae pallid on the basal half, reddish distally and onto the fore tarsi, fore-tarsal claws subequal, middle and hind pairs of femora yellow with yellow and brown hairs, tibiae paler with whitish and some sparse brown hairs outwardly, no hind-tibial fringe.

Abdomen evenly tapered, deep yellowish with brownish hairs, the sides and incisures narrowly yellow haired, the incisures very narrowly pale pillinose expanding mesally into subequal triangles on tergites 2 to 5, though they are somewhat rubbed in this specimen. The triangles are acuminate and appear to narrowly cross the tergites. Venter yellow with creamy hairs merging into brownish ones caudad of tergite 5.

Triumph, La., 20 July 1916, R. J. Jones. Named in commemoration of an eventful Christmas Day in Hamilton, 1946, during which it was described. In the collection of the author.

The over-all yellowish to tan color, robust build, slender palpi, and wings without the furcation or costal cell clouded, relate this to no described female of the writer's acquaintance. It has been held a long time in the hopes the female would turn up. In addition to its more yellowish color, etc., the area of enlarged facets is more sharply demarcated than in *equalis*, less extensive than in *melanocerus* and *lacustris*, and it lacks the pale, contrasting scutellum of other species of the *molestus* group to which it seems to belong. In Stone's (1938) key to males, it keys out at couplet 25, where the paler color, larger triangles, and strongly bicolored fore tibiae differentiate it. The hypothetical female would probably key to *melanocerus* (couplet 72) from which it should likely be separated by much paler body and femoral colors, hyaline costal cells, and possibly more slender, yellower palpi.

Tabanus melanocerus Wied.

Typically the triangles are a series of well separated, equilateral angular spots, the wings are hyaline and hind femora pallid. Variations occur in the direction of *lacustris* Stone (subsp., Philip 1950a), and of *petiolatus* Hine in which the triangle on tergite 2 not only crosses it but expands anteriorly, and cell R₅ is closed and even petiolate, but the front remains characteristic. A male of this form from Georgia has almost totally dark fore and hind femora, and a wide mid-ventral black band. Further specimens of both sexes are needed to determine the extent of variation and melanism in this species.

Tabanus endymion O. S.

The peculiarity of the W-shaped dark mark on tergite 2 of some unworn specimens has not been called to attention. The lateral "arms" of the "W" are rather flat, diagonal dashes dividing the widened postero-lateral pale incisures from sublateral, anterior pale spots on either side of the inverted "V"; the latter are accentuated by pale hair patches which are easily worn. Males of this are difficult to associate in this group because of the obscuring of the median triangles by wide, pale, incisural bands.

Tabanus coarctatus Stone

Some smaller variants of *T. equalis* Hine cause confusion here, there being some variation in the shape of the third antennal segment as in the case of the following species. It is to be hoped that the unknown male of this will be discovered soon.

Tabanus turbidus Wied.

Like some *T. cheliopterus* Rond., there is puzzling variation, especially in size, and in relative lengths of annuli and plate of the third antennal

segment. There may be more than one form present even since the separation of *T. aar* Philip. The last, however, almost never has evident triangles because the customary greasing obscures the underlying pale pollenosity.

Two variants have also shown up from Louisiana with the wings less strongly fumose along the veins, but the cross veins and radial fork with blackish clouds more emphasized, and the antennae blackish on almost the entire third segment. The fronts and densely, pale-haired scutellums are identical with typical *turbidus*. More specimens may prove this to be a distinct variety. A specimen of *T. aar* Philip in the same lot from Dr. G. H. Penn provides a new Louisiana record for that species.

Tabanus kisliuki Stone

There is also remarkable disparity in size of this which, coupled with its rarity, causes some difficulty in assignment. A specimen of 14.5 mm. from Florala, Alabama, establishes the distribution considerably east of the previously-known, localized occurrence on the Gulf Coast of Mississippi.

KEY TO FEMALES

The following dichotomy is provided to supplement Stone's diagnostic treatment, and possibly to facilitate determination of variants under different arrangements of characters.

1. Pale triangle on tergite 2 absent or very much reduced; scutellum contrastingly pallid, accentuated by whitish appressed hairs on the disc in doubtful cases.. 2
   Pale triangle on tergite 2 not markedly smaller than those on tergite 3 and 4; scutellum usually with some black hairs on the disc, not strikingly pallid as a rule... 6
2. Fore tibiae bicolored, the basal half whitish; tergite 2 usually with no trace of a median triangle, but often a pair of sublateral isolated pale spots...**trimaculatus** Pal.
   Fore tibiae practically unicolorous in ground color, or if pale at the extreme base, there is a pale triangle on tergite 2............................... 3
3. Pale triangles small, the apical outlines often indistinct and usually fading short of the anterior margin of the tergites; eyes uniformly black in life...**superjumentarius** Whit.
   Pale triangles broad and distinct, usually crossing one or more of the tergites; eyes banded in life (scutellum without any black hairs on the disc)...... 4
4. Front narrow, index at least 6, basal callosity at least twice as high as wide; mid and hind tibiae predominantly whitish.........**moderator** Stone
   Frontal index not over 5, height of the callosity less than twice its width; legs not contrastingly colored.................................... 5
5. Beard, pleurae, and venter pale pilose and pollinose..........**molestus** Say
   Beard and pleurae brownish pilose and pollinose, the sternites usually dark with contrasting pale hind margins.............subsp. **mixis** nov.
6. Rather small species with bare or thinly dusted subcalli and unbanded eyes in life...**nigripes** Wied.
   Species mostly well over 15 mm. in length, and with dull pollinose subcalli... 7
7. Fore tibiae whitish basally; cell R_5 strongly narrowed or closed at the wing margin... 8
   Fore tibiae almost or quite unicolorous in ground color though there may be pale hairs basally on a reddish ground color, darker distally; cell R_5 variable..12
8. Wings with prominent clouds on the cross veins; antennae predominantly reddish; eyes banded in life...........................**sulcifrons** Macq.
   Wings without prominent clouds, though there may be a small one on the radial fork; antennae predominantly blackish or dark brown; eyes unbanded.. 9

9. Cell R_5 closed and usually petiolate; the pale spot on tergite 2 expanded
    anteriorly like an hourglass; front narrow, index about 7....**petiolatus** Hine
    Cell R_5 usually only narrowed at the margin; tergite 2 not usually crossed
    by the pale triangle; front wider...10
10. Third antennal segment black, or narrowly red at extreme base; body
    predominantly dark brown, the palpi gray and swollen basally, acuminate
    apically; costal cell usually tinted..11
    Antennae red to dorsal angle, dark brown beyond; body predominantly
    orange reddish with pale venter; palpi yellow, blunt apically; costal
    cell hyaline...............................[hypothetical ♀ **yulenus** n. sp.]
11. Spur-veinlet absent; hind tibiae darkened at apex only.....**melanocerus** Wied.
    Short spur at base of vein R_4; hind tibiae black on distal fourth or
    more..subsp. **lacustris** Stone
12. Wings brown with darker clouds on the cross veins; sternites black with
    broad, white hind margins.............................**trijunctus** Wlk.
    Differing in one or more of these characters.............................13
13. Front parallel sided, index 3 to 4; callosity nearly as wide as high.........14
    Front widened above, index 4½ and over; callosity usually much taller
    than broad...16
14. Beard white; wings subhyaline with isolated clouds on the cross veins;
    third antennal segment broad with no dorsal excision......**endymion** O. S.
    Beard yellow to brown; wings tinted or fumose with clouds; antennal plate
    dorsally excised..15
15. Usually larger species with dark brown, pale-banded abdomen,
                                                            cheliopterus Rond.
    Usually smaller species with yellow-red abdomen and pale incisures
    inconspicuous.....................................subsp. **subfronto** Phil.
16. Venter chocolate brown with rather narrow whitish incisures; wings hyaline
    with contrasting, deep yellow costal cells, and short spurs on R_4,
                                                                kisliuki Stone
    Differing in one or more of these characters.............................17
17. Wings, including costal cells, entirely hyaline (clouds, if present, faint);
    hind-tibial fringe black at least on distal half.............**rufofrater** Wlk.
    Wings with costal cells tinted and/or at least some veins or cross veins
    fumose margined; hind-tibial fringe predominantly pallid or reddish
    brown...18
18. All longitudinal veins margined with brown and costal cells deep yellow;
    scutellum with rather dense white appressed hairs; usually robust flies
    over 17 mm..**turbidus** Wied.
    Longitudinal veins not margined with brown though there may be clouds
    on the cross veins; costal cell tinted hardly more than basal cells;
    scutellum sparsely pale haired with a few black ones on the disc; usually
    under 17 mm..19
19. Frontal index 4½; third antennal segment with the annuli longer than
    the plate..**equalis** Hine
    Frontal index 5½ to 6; annuli shorter than the plate.......**coarctatus** Stone

TABULAR DATA ON KNOWN MALES

Of the females of species keyed above, the respective males of only *petiolatus* and *coarctatus* remain unknown, while the female of *yulenus* n. sp. is also still unrecognized. The males of many species can be identified by elimination in the foregoing key with allowance for sexual divergence. An additional aid is provided below, grouped mainly on the basis of the distribution of the enlarged eye facets. The divergence noted in males of *T. sulcifrons* in this regard emphasizes the need for caution in reliance on this character, but the present discussion, when taken as supplemental to the pertinent section of Stone's key to males (couplets 16 to 33, 1938), should provide fairly confident, diagnostic identity of the known species. It is a peculiar quality of this group that respective males often lack, or possess to a

reduced extent, the marked bicolored ground color of the fore tibiae exhibited in certain related females. Sexual dimorphism in coloration is most marked in *T. rufofrater* and *T. endymion*, while the failure of some *T. nigripes* males to show any median triangles is offset for diagnostic purposes by the peculiar, swollen, denuded frontal triangles.

I. Enlarged facets of eyes occupying upper two-thirds to three-fourths total area.
   A. Abdominal triangules reduced or wanting; frontal triangle denuded, shiny brown..**nigripes** Wied.
   B. Abdominal triangles prominent, confined to tergites 3–5.
      1. Abdomen dark, unbanded.......................**trimaculatus** Pal.
      2. Triangles resting on prominent incisural pale bands (tergite 2 also with band).................................**moderator** Stone
   C. Tergite 2 with large triangle like those on 3–5.
      1. Antennae largely black; beard white; wings without prominent clouds.
         a. R_4 without spur...........................**melanocerus** Wied.
         b. R_4 with spur and faint cloud.............subsp. **lacustris** Stone
      2. Third antennal segment largely red; beard yellow; wings brown with prominent clouds.
         a. Antennae wholly red; enlarged facets three-fourths total area......................................**cheliopterus** Rond.
         b. Scape and annuli dark; enlarged facets about two-thirds area (or even less) with broad occipital rim of small facets,
                      sulcifrons Macq.
II. Enlarged facets about half of total area but sharply demarcated.
   A. Abdominal triangles obscured, or wanting at least on tergite 2.
      1. Abdomen including venter dark, triangles small, confined to tergites 3–5; wings without isolated clouds...**superjumentarius** Whit.[1]
      2. Abdominal triangles obscured by wide incisural, pale bands; wings subhyaline with isolated clouds on the cross veins,
                      endymion O. S.
   B. Tergites 2–5 with prominent pale triangles.
      1. Wings hyaline, beard and basal half of fore tibiae whitish,
                      yulenus n. sp.
      2. Wings with fumose markings, beard yellowish to brown, fore tibiae unicolorous.
         a. Venter black with pale bands; outer fore-tarsal claw plainly elongated.....................................**trijunctus** Wlk.
         b. Venter reddish; fore-tarsal claws subequal........**turbidus** Wied.[2]
III. Upper area of facets very little enlarged, merging gradually with the lower with hardly noticeable line of demarcation.
   A. Dark-haired thorax, and pale abdomen in contrast, the triangles almost obscured by extensive albinism; scutellum pinkish margined with pale hairs......................................**rufofrater** Wlk.
   B. Pale triangles on tergites 3–5 but not 2; whitish pollinose scutellum contrasting to dark thorax.
      1. Face and pleurae gray pollinose; some sternites with wide white bands...**molestus** Say
      2. Entire body dark brown to blackish including venter which has very narrow yellowish incisures...................subsp. **mixis** nov.
   C. Pale triangle also present on tergite 2; scutellum concolorous with mesonotum in ground color.
      1. Legs and venter reddish with yellow hairs...........**equalis** Hine
      2. Legs brown with concolorous hairs; venter brown with contrasting, narrow pale incisures..............................**kisliuki** Stone

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[1]Specimens of *molestus* which might be confused here have contrasting, whitish scutellums.

[2]Some *sulcifrons* with reduced upper areas of facets will separate here with combination of black annuli, dark palpi, and extensively reddish venters.

SUMMARY

T. yulenus n. sp. (holotype ♂ from Louisiana) and *T. molestus* subsp. *mixis* nov. (holotype ♀ from Georgia, and ♂) are described as new.   Comments on other species of the *molestus-sulcifrons* group of *Tabanus s. str.* with a prominent row of pale abdominal triangles are given with a key to the species.

ADDENDA

In Part I, report of a stylopized *Chrysops wiedemanni* was erroneous. The specimen was examined by Dr. G. E. Bohart, and later dissection by the writer confirmed that there was merely close resemblance in location and shape of extraneous matter.

In Part II, a typographical error was missed in proof whereby the sex sign of the holotype of *Tabanus quirinus* (p. 120) was reversed. It was a male correctly indicated in Fig. 2.   A realignment of parts also caused its omission from the summary in Part II.

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Philip, C. B. 1941. Notes on Nearctic Tabanidae (Diptera). Part I. *Stenotabanus, Atylotus,* and *Tabanus s. str.* Canad. Ent., 73: 105–110.
   1950a. Corrections and addenda to a catalog of Nearctic Tabanidae. Am. Mid. Nat. (in press).
   1950b. New North American Tabanidae (Diptera). Part II. Tabanidae. Ann. Ent. Soc. Am., 43: 115–122.
Stone, Alan. 1938. The horseflies of the subfamily Tabanidae of the Nearctic Region. U. S. D. A. Misc. Pub. No. 305, 171 pp.

KORNIKI ZIEM POLSKI (LES BOSTRYCHES DE LA POLOGNE), by Jan Jerzy Karpinski and Konstanty Strawinski. Ann. Univ. Mariae Curie-Skłodowska, Supp. IV, Sect. C, pages 1–239. 28 plates, 100 text figures. 1948.

This appears to be an important work, in Polish with an extensive French summary (pp. 228–239), on the bark beetles of Poland. More than a hundred species are discussed in regard to their taxonomy, distribution, biologies, host relationships, natural enemies, economic significance, and control. Most of the illustrations consist of line drawings showing anatomical characters and of photographs of adults and of damage. Most of them are satisfactory although some of the photographs do not reproduce well.—M. T. J.

THE GENUS ACRORICNUS IN AMERICA

(Hymenoptera, Ichneumonidae)

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This paper is a revision of the known species of *Acroricnus* of America. Of the five previously described species assigned to this genus from this area, four are reduced to subspecific rank under the European genotype, *Acroricnus stylator* (Thunberg). Three subspecies and one species are described as new, and typical *stylator* is recorded from America for the first time.

Through the courtesy of E. T. Cresson, Jr. I was given access to all of Cresson's types and to other specimens of this genus in the collection of the Academy of Natural Sciences of Philadelphia. Other institutions and individuals that generously loaned material or gave me access to their specimens include the following: University of Alberta, California Academy of Sciences, Canadian National Collection, University of Colorado, Cornell University, R. R. Dreisbach (Midland, Mich.), H. R. Foxlee (Robson, B. C.), Iowa State College, University of Kansas, University of Minnesota, Ohio State University, Oregon State College, Patuxent Research Refuge (Laurel, Md.), Hewson H. Swift (New York City), P. H. Timberlake (Riverside, Calif.), Henry K. and Marjorie C. Townes (Raleigh, N. C.), U. S. National Museum.

I wish to express my gratitude for the cooperation of the above individuals and institutions and especially to Dr. Henry K. Townes for his invaluable guidance in the preparation of this paper.

Inasmuch as the original description of the genus is meager and includes characters which the study of additional material proves to be variable, the genus is redefined here. H. D. Pratt (1945. American Midland Naturalist 34:558) has given a key to distinguish *Acroricnus* from other Nearctic genera of Cryptini.

Acroricnus Ratzeburg

Acroricnus Ratzeburg, 1852. Ichneum. Forstins. 3: 92. Genotype: (*Acroricnus schaumii* Ratzeburg) = *stylator* Thunberg.
Xenocodon Foerster, 1855. Verh. Naturh. Ver. Preuss. Rheinlande 12: 237. Genotype: (*Xenocodon ruficornis* Foerster) = *seductor* Scopoli.
Macrobatus Holmgren, 1856. Svenska Vet-Akad. Handl. 75: 50. Genotype: (*Cryptus macrobates* Gravenhorst) = *stylator* Thunberg.
Linoceras Taschenberg, 1865. Ztschr. Gesammt. Naturw. 25: 8, 105. Genotype: (*Cryptus macrobates* Gravenhorst) = *stylator* Thunberg.
Leptobatides Buysson, 1896. Sp. Hymen. Eur. Alg. 6: 678, pl. 3. Genotype: *Leptobatides abeillei* Buysson.
Agathobanchus Ashmead, 1900. Proc. U. S. Nat. Mus. 23: 97. Genotype: (*Banchus aequatus* Say) = *stylator aequatus* Say.

Head broader than long; eyes bulged and slightly emarginate above antennal insertions; clypeus moderately convex, its apex truncate, and its basal groove arched; labrum prominent; malar space rather long, at least half the basal width of the mandible; mandible bidentate,

upper tooth broader and longer than lower; face slightly swollen; stemmaticum broad and moderately prominent; antenna longer than abdomen; pronotal groove obliquely crossed by a distinct carina (epomia); notallus shallow; sternaulus conspicuous; furrow along mesopleural suture deep and foveolate; mesopleurum with two depressions, one just beneath wings quite deep; prepectal carina present; median longitudinal groove on mesosternum deep; groove before scutellum broad and deep, limited on sides by strong lateral carinae; propodeum moderately convex and with two curved carinae; propodeal spiracles elongate; propodeum separated from metapleurum by a distinct foveolate furrow; thorax coarsely punctured and pubescent; petiole arched, about one-third the length of the abdomen, and with spiracles
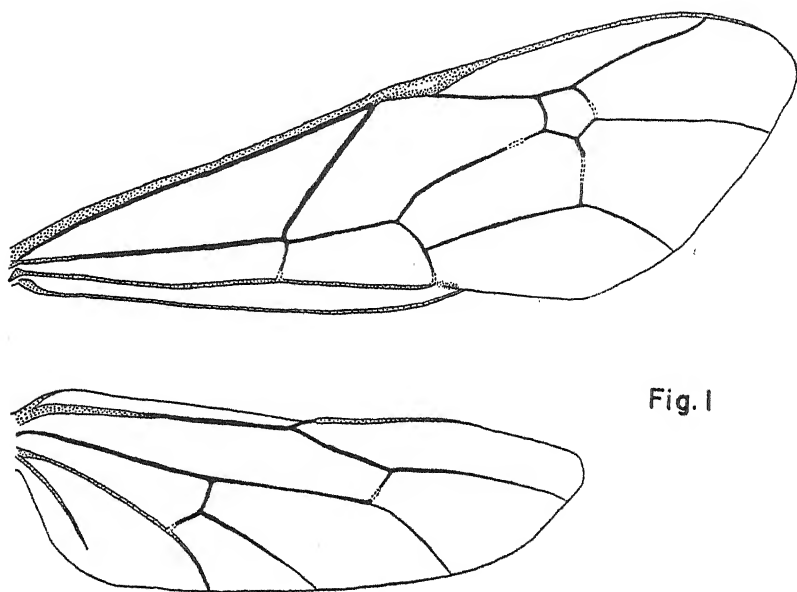
Fig. 1.

FIG. 1.   Forewing and hindwing of *Acroricnus stylator junceus* (Cresson).

slightly behind the middle; abdomen slender; legs long and slender with two ventral pair of spines on ultimate tarsal segment of hind leg; wings tinged yellowish; areolet large, 5-sided, the transverse cubital veins so shaped as to make the areolet appear tipped basad; nervellus broken a little above the middle; mediella almost straight in the apical half of its length; ovipositor shorter than abdomen but distinctly longer than thorax, its two lateral styli serrate at tip and enveloping the tip of the median stylus.

Observations of the male genitalia, which were found to be alike among the four formerly recognized species of the American mainland and even like the European genotype, and of the color pattern of these

species, which showed considerable variation and intergradation, gave conclusive evidence that these are all subspecies of the genotype, *Acroricnus stylator* (Thunberg). The sagitta of the male genitalia of *Acroricnus cubensis* (Cress.) and of the new species, *Acroricnus tricolor*, however, are more acuminate than of *Acroricnus stylator* (Thun.). Members of this genus are parasites of various species of mud wasps.

KEY TO THE AMERICAN SPECIES AND SUBSPECIES OF ACRORICNUS

1. Inner spur of hind tibia more than half the length of the basitarsus; prepectal carina complete, extending upward and forward to near the anterior margin of the mesopleurum; carinae of propodeum more distinct; groove between propodeum and metapleurum deep and strongly foveolate (fig. 2), (*stylator*). 2
   Inner spur of hind tibia not more than half the length of the basitarsus; prepectal carina incomplete above, not curved forward at its upper end; carinae of propodeum less distinct; groove between propodeum and metapleurum shallow and weakly foveolate (fig. 3). 9
2. Abdomen above prominently marked with yellow. . . . . stylator edwardsii
   Abdomen above not prominently marked with yellow. 3
3. Hind tibia entirely yellow. 4
   Hind tibia black apically. 6
4. Propodeum and/or metapleurum and/or hind coxa with yellow markings; scutellum entirely yellow. 5
   Propodeum, metapleurum, and hind coxa black; scutellum black or yellow, stylator aequatus
5. Hind femur entirely black or with a very narrow fulvous ring at extreme base. . . . . stylator junceus
   Hind femur broadly fulvous basally. . . . . stylator townesi
6. Propodeum and/or metapleurum and/or hind coxa with yellow markings; scutellum entirely yellow. 7
   Propodeum, metapleurum, and hind coxa black; scutellum black or yellow,

                                                                                                   8
7. Hind femur entirely black or with a very narrow fulvous ring at extreme base. . . . . stylator axilaris
   Hind femur broadly fulvous basally. . . . . stylator excelsus
8. Hind femur entirely fulvous. . . . . stylator stylator
   Hind femur black, broadly fulvous basally. . . . . stylator niger
9. Mesoscutum entirely rufous; occipital carina high and thin to its junction with hypostomal carina. . . . . tricolor
   Mesoscutum yellowish with dusky markings; occipital carina high and thin, abruptly tapering almost to obscurity at junction with hypostomal carina, which becomes broadly expanded beyond junction. . . . . cubensis

Acroricnus stylator (Thunberg)

Forewing averaging 9 mm. in female, 8.5 mm. in male. Shining; moderately hairy, pubescence of abdomen short and appressed; face broader than long, coarsely and densely punctate medially, densely but finely punctate laterally; clypeus twice as broad at apex as long and not so densely punctate; malar space about equal to basal width of mandible, finely and densely punctate; frons slightly concave, densely punctate and often rugose; temples moderately receding, more finely and sparsely punctate than face; junction of occipital and hypostomal carinae at a distance of about one and one-half times the basal width of the mandible before the mandible; thorax coarsely and densely punctate, more or less striately rugose on lower portion of the propleurum, central portion of the mesopleurum, and often on the metapleurum; sternaulus deep and foveolate; prepectal carina extending

upward and forward to anterior margin of the mesopleurum; apical half of propodeum rugose; suture separating propodeum from meta-pleurum deep and foveolate; four anterior coxae finely punctate, posterior coxae coarsely so; inner spur of hind tibia more than one-half the length of the basitarsus.

The coloration varies considerably and is the basis for dividing the species into subspecies as described below. Generally males have the face and clypeus yellow, whereas females have these parts black or sometimes tinged with yellow.

On the American mainland *Acroricnus stylator* (Thun.) presents an excellent example of subspeciation. On the accompanying map (fig. 4) the distribution of the known subspecies are indicated as well as could be ascertained from locality records of available specimens. Subspecies differing by only one color character are joined by arrows, solid when intergradation was observed and broken to indicate the probability
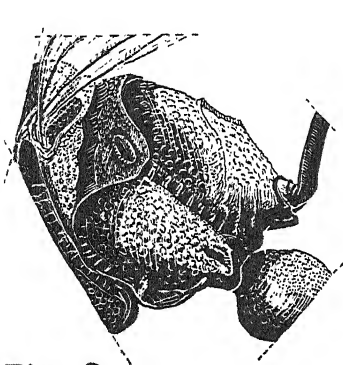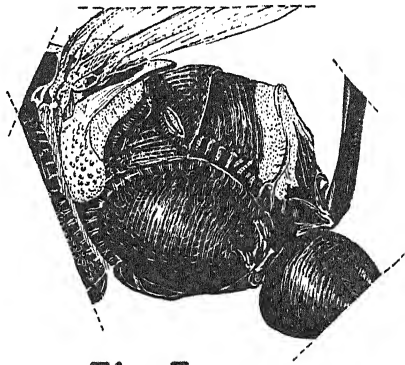
Fig. 2   Fig. 3

FIG. 2. Propodeum of *Acroricnus stylator junceus* (Cresson).
FIG. 3. Propodeum of *Acroricnus tricolor* Mitchell.
(Figs. 2 and 3 by John W. Brainerd, Springfield College, Springfield, Mass.)

of intergradation although no specimens were available to the author to substantiate it. It can be seen that subspecies so joined occupy adjacent areas.

The various subspecies are established on the color of the propodeum, hind femur, hind tibia, and abdomen. The known subspecies employ every possible color combination of these structures except the following one: propodeum and abdomen black, hind femur entirely black or with a very narrow fulvous ring at extreme base, and hind tibia black apically. A subspecies bearing such a color combination would vary from *niger*, *aequatus*, and *axilaris* by one color character each and likely exists in the area adjacent to the areas occupied by these three subspecies.

It is apparent that all of these subspecies are connected with *A. stylator stylator* (Thun.) through *A. stylator niger*, new subspecies, since *niger* is only one step removed from *stylator*.

Acroricnus stylator stylator (Thunberg)

1822. *Ichneumon stylator* Thunberg, Mem. acad. sc. St. Petersbourg 8: 265.
    (Type, male, Europe ?, Upsala).
1829. *Cryptus macrobatus* Gravenhorst, Ichneumon. Eur. 2: 440.
1853. *Acroricnus schaumii* Ratzeburg, Ichneum. Forstins. 3: 92.
1912. *Acrorhicnus stylator* (Thunberg) Roman, Die Ichneumonidentypen C. P.
    Thunbergs p. 281 (=*Acrorhicnus macrobatus* Grav.) (=*A. schaumii* Rat-
    zeburg).

*Thorax and abdomen black; hind femur entirely fulvous; hind tibia
yellow, black apically.*

Female.—Black; antenna fulvous, dusky above and with yellowish
annulus; anterior orbits, four anterior tibiae and tarsi and hind tarsi
excepting the apical segment, which is sometimes fuscous, yellowish;
apices of all trochanters and hind femora fulvous.

Male.—Similar to female except that face, clypeus, labrum, palpi,
and scape beneath, yellowish.

The above description was based on four specimens from Europe
and one specimen in the collection of the University of Minnesota
labeled "Can." It has been recorded as occurring in Asia, and inter-
grades between this subspecies and the following one were collected
at Eklutna Lake, Alaska, and Atlin, British Columbia. Its distribution
in North America appears to be limited to Alaska and northwestern
Canada.

Acroricnus stylator niger n. subsp.

*Thorax, except sometimes scutellum, and abdomen black; hind femur
fulvous, black apically; hind tibia yellow, black apically.*

Female.—Black; antenna fulvous, dusky above, and with whitish
annulus; scape beneath, anterior orbits, sometimes portions of face and
clypeus, generally the labrum, line on posterior orbit, tegula, often line
beneath, sometimes portions and rarely all of scutellum, anterior
trochanters partially to entirely, second joint of four hind trochanters,
four anterior femora and tibiae, hind tibia except apex, and tarsi,
yellow; hind femur fulvous, black apically.

Male.—Same color as female except that face, clypeus, labrum,
central portion of mandible, fore coxae generally partially to entirely,
anterior face of mid-coxae, all trochanters except upper portion of
basal joint of hind leg, yellow.

Holotype.— ♀, Robson, British Columbia, 7-VII-46, H. R. Foxlee
No. 5715 in the Canadian National Collection, Ottawa, Canada.

Allotype.— ♂, Robson, British Columbia, 1-VII-46, H. R. Foxlee,
[C. N. C.]

Paratypes.—ALASKA: ♂, Eklutna L., 11-VII-47, D. W. Jenkins,
[Mitch.] ALBERTA: ♂, Waterton, 8-VII-23, H. L. Seamans, [C. N. C.];
♂, Waterton, 10-VII-23, H. L. Seamans, [C. N. C.] BRITISH COLUMBIA:
♀, Merritt, 30-VIII-24, Auden?, [C. N. C.]; ♀, Robson, 7-VII-46,
H. R. Foxlee, [Mitch.]; ♀, Merritt, 10-VIII-23, R. Hopping, [C. N. C.];
♀, Osoyoos, 27-V-38, G. S. Walley, [C. N. C.]; ♀, Robson, 13-VIII-39,
H. R. Foxlee, [Minn.]; ♀, Vernon, 22-V-40, H. B. Leech, [C. A. S.];
♀, Fitzgerald, 29-VIII-21, R. Carter, [Townes]; ♀, Brilliant, 27-VI-44,
H. R. Foxlee, [Townes]; ♀, Robson, 31-VII-41, H. R. Foxlee, [Prov.
Mus.]; ♀, Vernon, 17-VII-41, [Townes]; ♀, Robson, 14-VII-47, H. R.
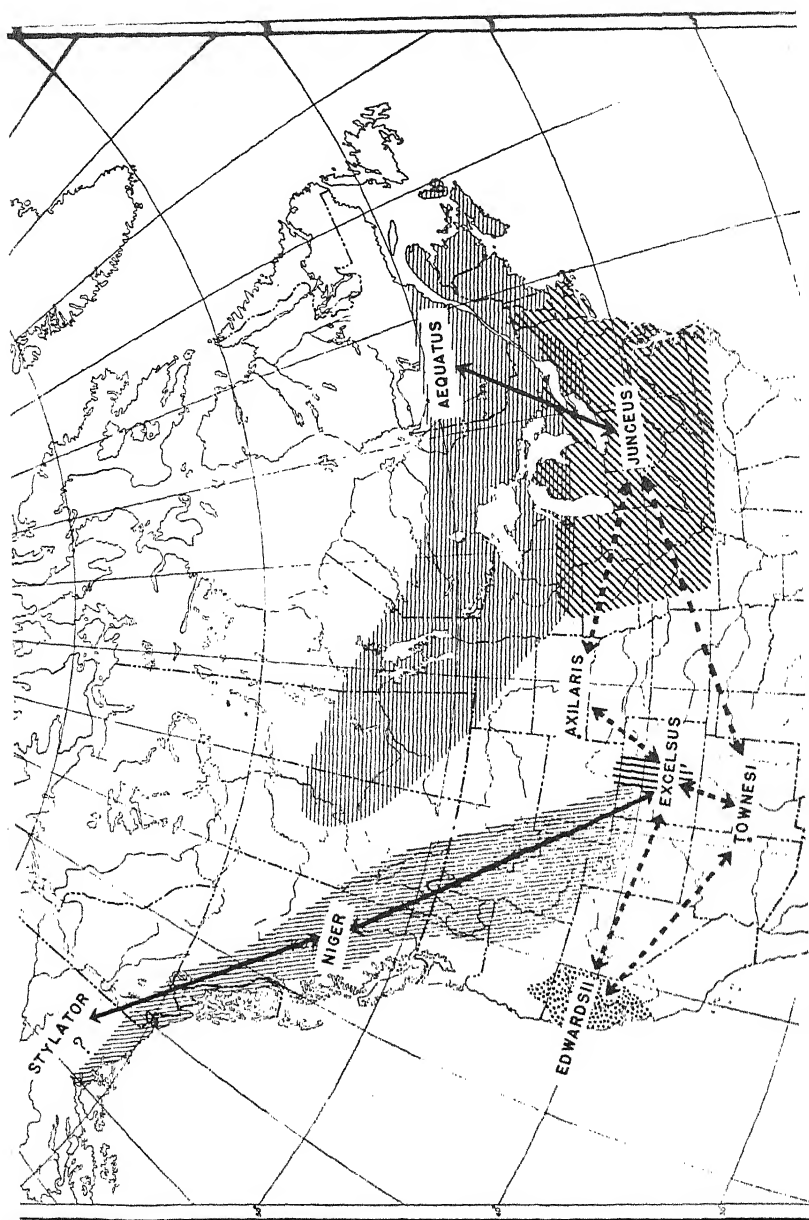
FIG. 4. Map showing distribution of subspecies of *Acroricnus stylator* on the American mainland.

Foxlee, [Foxlee]; ♀, Robson, 5-VII-47, H. R. Foxlee, [Mitch.]; ♀, Robson, 5-VI-47, H. R. Foxlee, [Mitch.]; ♀, Robson, 19-VIII-47, H. R. Foxlee, [Mitch.]; ♀, Robson, 24-VI-47, H. R. Foxlee, [C. N. C.]; ♀, Robson, 31-X-37, H. R. Foxlee, [C. N. C.]; ♀, Robson, 12-V-47, H. R. Foxlee, [Mitch.]; ♀, Carbonate to Prairie Hills, 12 to 18-VII-08, J. C. Bradley, [Mitch.]; 2♀, Carbonate to Prairie Hills, 7 to 12-VII-08, J. C. Bradley, [Cornell]; ♀, Vancouver, C. F. Baker, [U. S. N. M.]; ♀, Kaslo, 8-VII-06, [U. S. N. M.]; ♂, Robson, 26-V-46, H. R. Foxlee, [Mitch.]; ♂, Robson, 6-VII-46, H. R. Foxlee, [C. N. C.]; ♂, Lillooet, 15-VIII-23, A. Phair, [C. N. C.]; ♂, Kay Falls, 18-VII-25, R. Hopping, [C. N. C.]; ♂, Robson, 6-VIII-39, H. R. Foxlee, [Minn.]; ♂, Kaslo, 18-VII-?, A. N. Caudell, [U. S. N. M.]; ♂, Robson, 6-VII-46, H. R. Foxlee, [C. N. C.]; ♂, Trinity Valley, 15-VII-37, [Townes]; ♂, Robson, 17-VII-47, H. R. Foxlee, [C. N. C.]; ♂, Robson, 27-V-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 22-V-47, H. R. Foxlee, [C. N. C.]; ♂, Robson, 21-VI-47, H. R. Foxlee, [C. N. C.]; ♂, Robson, 28-VI-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 10-V-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 5-VI-47, H. R. Foxlee, [Prov. Mus.]; ♂, Robson, 10-VII-47, H. R. Foxlee, [Foxlee]; ♂, Robson, 19-V-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 28-VI-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 19-VII-47, H. R. Foxlee, [Mitch.]; ♂, Robson, 21-V-47, H. R. Foxlee, [Mitch.]; ♂, Carbonate to Prairie Hills, 7-12-VI-08, J. C. Bradley, [Mitch.]; 3♂, Carbonate to Prairie Hills, 7-12-VII-08, J. C. Bradley, [Cornell]; ♂, Atlin, 9-VII-29, Geo. Swarth, [U. S. N. M.]; ♂, Kaslo Cr., 18-VI-03, R. P. Currie, [U. S. N. M.]. COLORADO: ♂, Steamboat Springs, 23-VII-33, H. I. Gibbons, [Minn.]; ♂, Poudre R., VI-1883, [U. S. N. M.]; ♂, Poudre R., VI-1883, [U. S. N. M.]. IDAHO: Sex?, Beaver Can., VII-23, H. G. Hubbard, [U. S. N. M.]. MONTANA: ♂, Lake Ronan, Lake Co., 20-VI-32, R. D. Eichman, [Ore.]. OREGON: ♀, Onion Cr. Meadows, 18-VII-36, H. A. Scullen, [Ore.]. UTAH: ♀, Vivian Park, 7-VII-22, E. P. VanDuzee, [C. A. S.]; ♂, Park City, 3-VII-22, E. P. Van Duzee, [C. A. S.]. WASHINGTON: ♀, Almota, 25-V-13, M. A. Yothers, [Minn.]; ♀, Spokane, C. V. Piper, [U. S. N. M.]; ♂, Almota, [Minn.]; ♂, Wawawai, [Minn.].

This is the subspecies most closely allied to *A. stylator stylator*, differing from it only in having the apical portion of the hind femur black. The amount of black on the hind femora of the available specimens, all collected from southern British Columbia and southward, varies from one-half to two-thirds. Two specimens from southern Alaska and northern British Columbia have merely small apical areas of black. It is likely that in the progressive northern distribution of this subspecies the black coloration diminishes to complete absence.

At Robson, B. C., specimens were taken at altitudes from 1400 to 3200 feet. Specimens are reported to have been collected at parsley, and one was taken at light.

Acroricnus stylator excelsus (Cresson)

1864. *Cryptus excelsus* Cresson, Proc. Ent. Soc. Phila. 3: 293. (Type: female, Colorado, A.N.S.P.)
1887. *Linoceras excelsus* Cresson, Trans. Amer. Ent. Soc. suppl. vol., p. 198.
1944. *Acroricnus excelsus* Townes, Mem. Amer. Ent. Soc. 11: 297.

Abdomen black; propodeum marked with yellow; hind femur broadly fulvous basally; hind tibia yellow, black apically.

A composite description of this subspecies, based upon the study of fifteen females and seven males, follows.

Female.—Black; antennae fulvous below, more or less fuscous above and with yellowish annulus; scape beneath, face and clypeus partially to entirely, labrum, palpi, anterior orbits, a short line on posterior orbits, generally a small spot on pronotal collar, tegula, generally line beneath, spot on propodeum and often on metapleurum, sometimes area behind posterior wing, scutellum, post-scutellum, four anterior coxae partially, sometimes spot on posterior coxae, four anterior trochanters and tibiae, tarsi, and basal two-thirds of hind tibia yellow; second joint of trochanter of hind leg and basal one-third to one-half of hind femur, and sometimes sides of petiole fulvous.

Male.—Differs from female in having face, clypeus, mandibles, and labrum entirely yellow and more yellow on four anterior coxae.

Available material of this subspecies showed considerable variation in the extent of yellow coloration to the propodeum, metapleurum, the area behind the posterior wing and posterior coxae. The propodeum of all specimens of this subspecies taken in Colorado were quite broadly marked with yellow, thus complying in this respect with Cresson's original description of the species. A specimen in the Canadian National Collection labeled only British Columbia and presumed to have been taken near Vancouver had a yellow scutellum and a yellow mark on the propodeum much smaller than that of typical *excelsus*. This specimen together with the general tendency of the yellow coloration to vary give evidence of intergradation between *A. stylator excelsus* (Cresson) and *A. stylator niger* new subspecies.

Locality records for this subspecies include Boulder, Clear Creek, Cripple Creek, and Fort Collins, Colorado, and Vancouver?, British Columbia. The record from Alberta published by Strickland (1946, Canad. Ent. 78:41) is based on a misdetermined specimen of *Mesoleptus* or *Atractodes*.

Specimens have been taken on the wing from April 30 to July 24. The specimen from Cripple Creek, Colorado, was collected at an altitude of 8,930 feet.

Acroricnus stylator townesi n. subsp.

Abdomen black; scutellum yellow; propodeum marked with yellow; hind femur broadly fulvous basally; hind tibia entirely yellow.

The series upon which the description of this subspecies is based consists of one female and fifty-eigth males, all collected by Henry and Marjorie Townes near Alpine, Arizona.

Female.—Black; antennae yellow beneath, fuscous above and with yellowish annulus; scape beneath, face, clypeus, anterior and posterior orbits, spots on upper posterior margin of pronotum, tegulae, scutellum, postscutellum, large portion of propodeum, spot on metapleurum, area behind posterior wings, front of anterior and middle coxae, anterior trochanters, second segments of middle trochanters, four anterior femora, all tibiae and tarsi yellow; second segment of hind trochanters and base of hind femora fulvous.

Male.—Black; antennae yellow beneath, fuscous above and with yellowish annulus; face, clypeus, labrum, mandibles, line on posterior

orbits, often spots on upper posterior margin of pronotum, tegula, often line beneath, scutellum, postscutellum, large spot on propodeum, sometimes greatly reduced, sometimes area behind posterior wing, generally spot on metapleurum, rarely spot on hind coxa, most of four anterior coxae, four anterior trochanters, and all tibiae and tarsi yellow; second segment of hind trochanter and basal one-fourth or so fulvous.

The same variation in color undoubtedly exists in the female as in the male.

Holotype.— ♀, nr. Alpine, Arizona, 27-V-47, H. & M. Townes [Townes].

Allotype.—♂, nr. Alpine, Arizona, 24-V-47, H.&M. Townes [Townes].

Paratypes.—ARIZONA: 30♂, nr. Alpine, 24 to 30-V-47, H.&M. Townes, [Townes]; 24♂, nr. Alpine, 24 to 31-V-47, H.&M. Townes, [Mitchell]; 2♂, nr. Alpine, 26-V-47, H.&M. Townes, [C. N. C.]; ♂, nr. Alpine, 29-V-47, H.&M. Townes, [Cornell].

These specimens were all collected along the east fork of the Black River about one mile above Diamond Rock at an altitude of about 8300 feet.

This subspecies is intermediate between *A. stylator excelsus* (Cresson) and *A. stylator junceus* (Cresson), differing from the former and like the latter in having its hind tibia entirely yellow, and like the former and differing from the latter in having its hind femur broadly fulvous basally.

Acroricnus stylator junceus (Cresson)

1864. *Cryptus junceus* Cresson, Proc. Ent. Soc. Phila. 3: 295.   (Type: female, Illinois, A.N.S.P.)
1869. *C. junceus* Walsh & Riley, Amer. Ent. 1: 137 (fig., biol.).
1880. *C. junceus* Riley, Amer. Ent. 3:154.
1887. *Linoceras junceus* Cresson, Trans. Amer. Ent. Soc. suppl. vol., p. 198.
1900. *Osprynochotus junceus* Smith, Ann. Rpt. N. J. Bd. Agr. 27, suppl., p. 570 (N. Y.).
1910. *Acroricnus junceus* Viereck, Ann. Rpt. N. J. Mus. for 1909, p. 630.
1917. *A. junceus* Viereck, Bull. Conn. Geol. Nat. Hist. Surv. 22: 330 (Conn.).
1922. *A. junceus* Champlain, Psyche 29:99 (Pa.).
1926. *A. junceus* Bradley, Bull. Lloyd Librar. 27: 169 (N. Y.).
1928. *A. junceus* Cushman, in Leonard, Mem. Cornell Univ. Agr. Expt. Sta. 101: 930 (N. Y.).
1938. *A. junceus* Brimley, Ins. of N. C., p. 406 (N. C.).
1944. *A aequatus junceus* Townes, Mem. Amer. Ent. Soc. 11: 297.

Abdomen black; scutellum yellow; propodeum marked with yellow; hind femur black; hind tibia entirely yellow.

A composite description of this subspecies, based upon the study of fifty-five females and twenty-six males follows.

Female.—Black; antennae yellowish, fuscous above and with yellowish annulus; scape beneath, face, clypeus, labrum, anterior orbits, line on posterior orbits, spot on pronotal collar, usually spot on upper posterior edge of pronotum, tegulae, usually line beneath, scutellum, postscutellum, area of propodeum (usually large), usually spot on metapleurum, often area behind rear wing, anterior face (at least) of front coxae, usually portions of middle coxae, usually spot on hind coxae, tibiae, tarsi, yellow.

Male.—Like female except face and usually checks, mandibles, front and middle coxae almost entirely, yellow.

Upon examination of more than 150 specimens of this and the following subspecies complete intergradation was observed from the typical form of *junceus* occurring consistantly in specimens in the southern part of their combined ranges to the typical dark form of *aequatus* occurring equally consistently in the northern part of their combined ranges. There appeared to be a correlation between the occurrence of these forms and the Merriam life zones in the East. No typical *junceus* has been observed from the Canadian Zone nor has any typical *aequatus* been seen from the Austral Zone, yet typical forms of both, but mostly intergrades, have been taken in the Transition.

The known range of this subspecies extends from North Carolina north to Vermont, southern Quebec and Ontario west to southern Minnesota and south to Missouri.

In the latitude of Maryland this insect occurs on the wing from late May to early October. Some specimens have been collected from blossoms of *Daucus carota* L.

Hosts recorded for this subspecies include *Ancistrocerus birenimaculatus* (Sauss.), *Ancistrocerus tigris* (Sauss.), and *Sceliphron caementarium* (Drury).

Acroricnus stylator aequatus (Say)

1836. *Banchus aequatus* Say, Boston Jl. Nat. Hist. 1: 247 (Leconte Ed. 2:701). (Type: male, Indiana; type destroyed).
1874. *Atractodes Cloutieri* Provancher, Nat. Canad. 6: 150. (Type: female, Quebec, M.P.Q.).
1874. *A. Cloutieri* Prov., Nat. Canad. 7: 333.
1879. *Linoceras Cloutieri* Prov., Nat. Canad. 11: 110.
1887. *L. Cloutieri* Cresson, Trans. Amer. Ent. Soc. suppl. vol., p. 198.
1896. *L. Cloutieri* Evans, Canad. Ent. 28: 10 (Ont.).
1900. *Agathobanchus aequatus* Ashmead, Proc. U. S. Nat. Mus. 23: 97 (syn.).
1902. *Osprynchotus cloutieri* Dalla Torre, Cat. Hymen. 3: 598.
1905. *Banchus aequatus* Viereck, Trans. Kans. Acad. Sci. 19: 304. (syn.).
1921. *Acroricnus aequatus* Cushman & Gahan, Proc. Ent. Soc. Wash. 23: 158 (syn.).
1927. *A. cloutieri* Johnson, Biol. Surv. Mt. Desert Region 1: 140 (Maine).
1928. *A. aequatus* Criddle, Ann. Rpt. Ent. Soc. Ont. 58: 101 (Alta.).
1944. *A. aequatus aequatus* Townes, Mem. Amer. Ent. Soc. 11: 296.
1946. *A. aequatus aequatus* Strickland, Canad. Ent. 78: 41 (Alta.).

Thorax (except sometimes scutellum) and abdomen black; hind tibia entirely yellow; hind femur black.

A composite description of this subspecies, based upon the study of fifty females and fifty-one males, follows.

Female.—Black; antenna yellow, fuscous above and with yellowish annulus, scape beneath, usually clypeus and labrum, rarely face, palpi, anterior orbit, line on posterior orbit, rarely spot on pronotal collar, sometimes scutellum and post-scutellum partially, rarely entirely, tegula partially to completely, anterior coxa sometimes partially, four anterior trochanters partially, four anterior femora, and all tibiae and tarsi yellow.

Male.—Same color as female except face, clypeus, labrum, mandible, and usually cheek yellow and with more yellow on four anterior coxae and trochanters.

The known range of this subspecies extends from Nova Scotia and Prince Edward Island west to Alberta, southeast to southern Minnesota

and east through central Michigan and south central New York to Maine.

Specimens have been collected from early June to early September. A specimen was reared from *Eumenes fraternus* Say by H. E. Milliron at Itasca Park, Minnesota.

Acroricnus stylator axilaris, new subspecies

Abdoman black; propodeum marked with yellow; hind tibia yellow, black apically; hind femur black.

Female.—Black; antenna yellowish, fuscous above and with yellowish annulus, scape beneath, two spots on face, middle of clypeus, labrum, anterior orbit, line on posterior orbit, tegula, scutellum, postscutellum, spot on propodeum, spot on anterior face of front coxa and trochanters, second segment of middle trochanter, four anterior femora and tibiae, hind tibia except for black apex, and all tarsi yellow; hind femur narrowly fulvous basally.

Holotype.—Female, Harney Peak, S. Dak., 21-VII-24, [No. 58819 U. S. N. M.]

Acroricnus stylator excelsus (Cr.) and *A. stylator junceus* (Cr.) differ from each other by two color characters. The hind femur is broadly fulvous basally and the hind tibia black apically in *excelsus*, whereas in *junceus* the hind femur is entirely black or with only a narrow ring of fulvous at the base and the hind tibia entirely yellow. Considering the amount of variation observed in the width of the fulvous area at the base of the hind femur in *excelsus*, specimens undoubtedly exist with only a narrow fulvous ring as in *junceus*. The above specimen, which bears a fulvous ring narrower than in typical *excelsus* and broader than in *junceus*, may therefore be considered an intergrade between *excelsus* and my theoretic concept of typical *axilaris*.

Acroricnus stylator edwardsii (Cresson)

1878. *Linoceras Edwardsii* Cresson, Proc. Acad. Nat. Sci. Phila. p. 365. (Type: male, California, H. Edwards, A.N.S.P.).
1887. *L. Edwardsii* Cresson, Trans. Amer. Ent. Soc. suppl. vol., p. 198.
1902. *Osprynchotus edwardsii* Dalla Torre, Cat. Hymen. 3: 598 (syn.).
1944. *Acroricnus edwardsii* Townes, Mem. Amer. Ent. Soc. 11: 297.

Tergites partially yellow.

A composite description of this subspecies, based upon the study of twenty-one females and seventeen males, follows.

Female.—Black; antenna yellowish to fulvous below, fuscous above, and with a yellowish annulus; scape beneath, anterior and posterior orbits, face, clypeus, labrum, mandible, pronotal collar, irregular spots on pronotum and mesoscutum, tegula, line beneath, rarely patches on mesopleurum, scutellum, postscutellum, area behind rear wing, spot on metapleurum, usually large portion of propodeum, often spot on hind coxa, usually most of four anterior coxae, usually all of hind tibia, and usually almost all of the abdomen, yellow; hind femur yellow with the apical half or less blackish, sometimes entirely yellow and rarely only narrowly yellow at the base.

Male.—Like female except propodeum, metapleurum, area behind rear wing, and hind coxa often without yellow markings; base of hind

femur only narrowly yellow basally; apical black spot on hind tibia; apical tergites usually entirely black.

The known range of this subspecies extends from central California north to southern Oregon. It has been collected from late April to mid-August.

Acroricnus cubensis (Cresson)

1865. *Cryptus cubensis* Cresson, Proc. Ent. Soc. Phila. 4: 21. (Type: female, Cuba, A.N.S.P.).
1910. *Acroricnus cubensis* Roman, Ent. Tidsk. 31: 143.

Dull yellowish shaded with dusky; petiole and first few abdominal segments black basally; hind tibia black apically; wings yellowish hyaline, slightly dusky apically.

Female.—Forewing averaging 11.5 mm. Matte, densely clothed with short golden pubescence; face coarsely and densely punctate medially, densely but finely punctate laterally; clypeus twice as broad at apex as long and not so densely punctate; malar space almost equal to basal width of mandible, finely and densely punctate; frons slightly concave and densely punctate; temples moderately receding, more sparsely and finely punctate than face; occipital carina high and thin, abruptly tapering almost to obscurity at junction with hypostomal carina, which becomes broadly expanded beyond junction; junction of carinae at a distance greater than two times the basal width of the mandible before the mandible; thorax coarsely and densely punctate, finely and irregularly striate on the sides; prepectal carina short, not curved forward at its upper end; apical half of propodeum irregularly striate; furrows behind basal carina of propodeum and those separating propodeum from metapleurum not especially deep nor strongly foveolate; posterior face of propodeum slightly concave; inner spur of hind tibia not more than half the length of the basi-tarsus.

Dull yellowish; antenna fulvous, dusky above and at tips and with yellowish annulus; pronotum, mesoscutum, and mesopleurum with dusky stains; mesosternum, base of propodeum, base of metapleurum, hind coxa beneath, hind trochanters, broad band near apex of hind femur, and apex of hind tibia black; petiole and first few abdominal tergites black basally, shading through dusky to yellowish at apices, the following tergites shading from dusky or somewhat rufous to yellowish at apices; wings yellowish hyaline, apical margins slightly dusky; hind tarsi dusky apically.

Male.—Forewing averaging 11 mm. Like female except that the abdominal tergites are basally blacker. One male specimen in the collection of the U. S. National Museum has hind coxae entirely yellow.

This species has twice been recorded as a parasite of *Sceliphron caementarium* (Drury).

Specimens have been taken at Cienfuegos, Santiago de la Vegas, and "La Havane," Cuba.

Acroricnus tricolor n. sp.

Mesoscutum rufous.

Female.—Forewing averaging 11.0 mm. Somewhat shining, clothed with short golden pubescence; face coarsely and densely punctate

medially, densely but finely punctate laterally; clypeus twice as broad at apex as long and not so densely punctate; malar space almost equal to basal width of mandible, finely and densely punctate; temples moderately receeding, more sparsely and finely punctate than face; occipital carina high and thin and equal to height of hypostomal carina at junction with hypostomal carina which tapers gradually to base of mandible.   Junction of carinae at a distance of about twice the basal width of the mandible before the mandible; thorax coarsely and densely punctate; prepectal carina short, not curved forward at its upper end; side of prothorax and apical portion of propodeum irregularly striate; furrow behind basal carina of propodeum and those separating the propodeum from the metapleurum not especially deep nor strongly foveolate; posterior face of propodeum more or less flat; inner spur of hind tibia not more than half the length of the basitarsus.

Head rufous; orbits, labrum, and palpi, yellowish; stemmaticum, frons, and tips of mandibles, black; antenna fulvous, fuscous above and with yellow annulus; prothoracic collar, tegula, upper posterior margin of prothorax, scutellum, postscutellum, scutellar carinae, large irregular mesopleural spot and area behind hind wings yellow, the rest of the thorax black except that the prothorax and mesoscutum are rufous; propodeum black at base and broadly yellow on apical third excepting a small black spot at base of petiole; petiole and base of second abdominal tergite black; postpetiole yellow and apex of following tergites broadly yellow; base of all abdominal tergites beyond second dull rufous; ovipositor mahogheny, its sheaths black; anterior coxae and trochanters yellow tinged with black; four posterior coxae and trochanters black, the latter of the mid-leg tinged with yellow; femora, tibiae, and tarsi yellow, excepting posterior half of hind femora and apex of hind tibiae which are black and ventral area of mid femora and terminal segments of hind tarsi which are fuscous; wings yellowish, smoky apically.

Male.—The forewing of the only male available to the author measures 12.5 mm.   It differs in color from the females by the yellow annulus of the antenna being obscure, face and mandible yellow, propleurum black, and the yellow margin before the mesoscutum broad.

Holotype.— ♀, Port au Prince, Haiti, Aug. 1927, G. N. Wolcott [U. S. N. M. no. 58818].

Allotype.—♂, Rio Piedras, Puerto Rico, 4-IX-23, [U. S. N. M.] (parasite of *Eumenes abdominalis* of authors = *confusus* Bequaert & Salt).

Paratypes.— ♀, San Domingo, G. N. Wolcott, [U. S. N. M.] (parasite of *Sceliphron caementarium* (Dru.)).   ♀, Cape Haitien, Haiti, 7-VII-31, Kisliuk & Cooley [Mitch.].

STUDIES ON AEDES VEXANS (MEIG.) AND AEDES STICTICUS (MEIG.), FLOOD-WATER MOSQUITOES, IN THE LOWER COLUMBIA RIVER VALLEY

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The annual spring floods of the Columbia River usually inundate thousands of acres of open and wooded lowlands along its borders below Bonneville Dam for a distance of about 60 miles or more up and down the river from Vancouver, Wash., and Portland, Oreg. The Willamette River floods smaller areas for about 15 miles above the point where it joins the Columbia, and considerable backing up of water occurs near the mouths of smaller tributaries in this region. The area that flooded above the site of the Bonneville Dam before it was built is now permanently covered with water (Stage, 1943).

Most of these flooded lowlands are partially wooded with willows and cottonwoods and serve as ideal breeding places for the floodwater mosquitoes *Aedes vexans* (Meig.) and *A. sticticus* (Meig.). These species are a serious pest during June, July, and August, and mosquito-abatement work has been carried on for many years by the city of Portland and by Multnomah County, Oregon. Control measures included the use of larvicides, the clearing of brush, and the construction of dykes and fills. Other changes in the region have resulted from dredging the river and dumping sand along the shores.

EGGS

Description and development.—*Aedes vexans* eggs are spindle-shaped and usually symmetrical, with black faintly reticulated shells. They range from 0.61 to 0.645 mm. in length and from 0.18 to 0.215 mm. in width. *A. sticticus* eggs are almost straight along one side and have a distinct bulge slightly beyond the center on the other side. They range from 0.51 to 0.61 mm. in length and from 0.2 to 0.215 mm. in width. The shell is black and reticulated.

Information on embryo development of eggs was obtained by dissecting and examining 125 eggs (out of a lot of 300) laid by several caged females. The females were taken in nature in August and given blood meals after they were caged. Partial development of the embryo was observed in some of the eggs on the first day after they were laid, and in 81 percent of the eggs that were 1 to 3 days old. Development was complete in 9 percent of the eggs 4 to 6 days old in 75 percent of the eggs 8 to 10 days old. In one lot of eggs laid by three females, only 57 percent were completely developed on the thirteenth day. The other 43 percent were undeveloped or only partially developed.

Five percent of a lot of 22,000 *Aedes vexans* and 2,650 *A. sticticus* eggs were dissected 10 to 12 days after they were laid. These eggs were laid in cages in the laboratory by females taken in nature after they had fed on blood from a horse. The number of completely devel-

oped embryos ranged from 56 to 82 percent of the total for *vexans* eggs laid from June 25 to August 25, and from 61 to 75 percent for *sticticus* eggs laid from July 10 to August 7.

The eggs of both these species hatch as soon as the embryo has completed its development.   Larvae have been hatched from *Aedes vexans* eggs 3 to 5 days after they were laid in the laboratory.

Conditions required for hatching.—Gjullin *et al.*   (1939) found that eggs of *Aedes vexans* and *A. sticticus* (= *aldrichi* Dyar and Knab) would not hatch in tap water or in water taken directly from the Columbia River, and that the eggs would hatch readily in willow-leaf infusions made with tap water and in water containing small amounts of certain amino acids and potassium phosphate.   Asparagine and glycine were the most effective of these amino acids.   In later studies Gjullin *et al.* (1941) found that the eggs hatched because of a reduction of the dissolved oxygen in the water of these infusions and solutions.   In the laboratory this was easily accomplished by the reducing action of bacteria, yeasts, and molds in asparagine-phosphate solutions, and by the oxidation of organic tissues, such as those in carrots and potatoes. Mechanical or chemical removal of oxygen also caused hatching.

Further experiments with the eggs of these species have shown that the reduction of the dissolved oxygen in water is the chief factor governing hatching in nature.   In tests with eggs of *Aedes vexans* placed on the surface of the soil and also 3 inches above the soil surface of a flooded soil sample, 80 percent of the eggs hatched at soil level and 28 percent in the water in 6 hours.   Evidently the maximum reduction of oxygen takes place most quickly on, or just below, the surface of the soil where the eggs are laid.

Tests were also made to determine whether other substances in the water which had been in contact with the soil might be responsible for the hatching of the eggs.   A funnel equipped with a stopcock at the bottom and lined with a cloth filter was filled with soil and humus and covered with water.   After 3 hours the water was drawn off at the bottom of the funnel.   A portion of this water was aerated by sucking air through it with a suction pump.   Twenty-five *Aedes vexans* eggs placed in weighed cloth bags were then added, and aeration was continued for 3 to 12 hours.   The eggs were then removed and the percentage of hatch was noted.   Of the 300 eggs used in these tests only 10 percent hatched, whereas in water from the same funnel, which had not been aerated, 75 percent hatched.   From these tests we believe that most of the eggs laid in nature by this species are stimulated to hatch by the reduction of the oxygen in the water.   The amount of oxygen reduction required to cause hatching in nature will undoubtedly vary with temperature and other factors.   In the laboratory hatching began when the oxygen was reduced to about 4 parts per million, but further reduction is usually necessary before all the eggs will hatch.

In temporary floods which cause hatching of *Aedes vexans* and *A. sticticus* eggs in nature, the newly hatched larvae are found only in shallow, quiet waters.   No hatching occurs in running water, and little or no hatching in areas that are quickly and deeply flooded.   These conditions are unfavorable for the reduction of oxygen by bacteria and organic material, and the exchange of water at the soil surface prevents

appreciable lowering of the oxygen content. Therefore, the reduction of dissolved oxygen in the water serves as a regulating mechanism, which insures that the eggs will hatch only in a favorable environment of shallow water having an abundance of food material for the larvae.

In the Columbia River Valley the eggs of *Aedes vexans* and *A. sticticus* are dormant and will not hatch when they are flooded during the winter months. Apparently winter dormancy is caused entirely by low temperatures, because complete hatches of winter dormant eggs have been obtained consistently from soil samples taken in mid-winter and kept at 100°F. for 48 hours before flooding. A temperature of 70° to 80°F. for 7 to 10 days is equally effective in breaking the dormant cycle during this time of the year. When the eggs first become dormant in the fall months higher temperatures are not effective in breaking the dormant cycle. Data which were accumulated in a study of the survival of the eggs of these species in nature (Table I) showed that more than half of the eggs were dormant in September and that a temperature of 70°F. for 2 to 4 weeks caused only a slight increase in the numbers that hatched. Reduced daylight in the fall and winter months appears to have no effect on the dormancy of the eggs of these species.

Data on the relationship between temperature and egg dormancy were obtained from soil samples taken in nature. Six samples consisting of about 2 quarts of soil and debris per sample were taken each week from April 1, 1936 to June 30, 1947. The samples were flooded at outdoor temperatures, and the larvae that hatched were counted. The soil was then brought into the laboratory, where it was dried and reflooded at room temperature until no further hatching occurred. The percentage of hatch in the first flooding was based on the total numbers of larvae hatched. This percentage represents the eggs that would have hatched in nature if the areas had been flooded at that time. No eggs hatched in these samples at outdoor temperatures during the winter months. The eggs of these species are completely dormant when temperatures remain below 45° to 50°F. The relation between temperature and percentage of hatch is shown for the fall months of 1936 and the spring months of 1937 in the graph in figure 1. During the spring of 1937 complete hatches of the eggs in the soil samples did not occur until June 8. The Columbia River began to flood these areas about May 12, when many of the eggs were still dormant. The date on which complete hatching occurs varies with the spring temperatures of each season. This point was reached by May 8 in 1939 and by April 18 in 1941.

Partial hatches of the eggs in the areas flooded by the Columbia and Willamette Rivers frequently occur in nature. They are caused both by the partial winter dormancy of the eggs and by rapid rises of the rivers, which flood the egg-beds deeply and prevent sufficient reduction of oxygen for hatching. Many viable eggs have been recovered from the soil under the water in these areas several weeks after they were flooded. Additional hatches occur in these egg-beds if the flood waters recede for a few days and then rise and cover them again.

Effect of flooding on hatching.—The time required for eggs of these species to hatch after they have been flooded varies with the degree

of dormancy and with the temperature of the water at the time of flooding. For example, hatching began in 1 hour in soil samples taken in May and flooded with water at a temperature of 70°F. Soil samples flooded in April with water at 70° produced a hatch of 34 percent during the first hour and 88 percent in two hours.

Only a small percentage of *Aedes vexans* and *A. sticticus* eggs hatch when water stands over the eggs continuously from late winter through the spring and summer months. Soil samples containing the eggs of these species were flooded under outdoor conditions in January and March, while the eggs were still in a winter dormant condition, and kept under water until May. Only 2 percent of the *vexans* and 6 percent
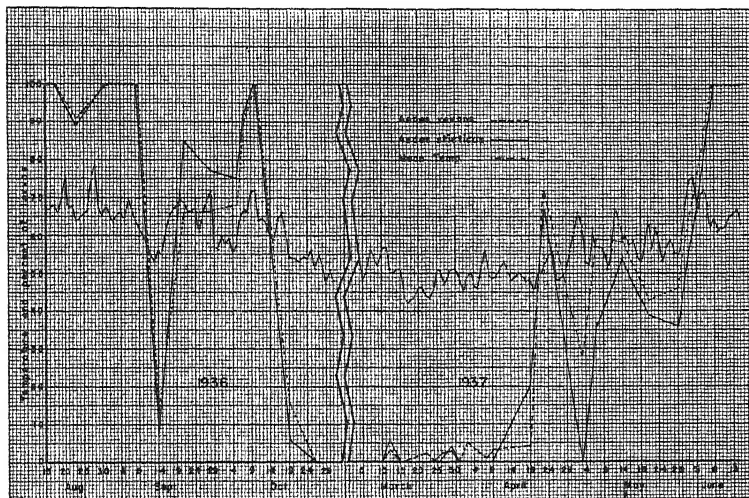
Fig. 1. Percentage of *Aedes vexans* and *A. sticticus* larvae hatching from the first flooding of soil samples under outdoor temperatures. No hatching occurred at outdoor temperatures from October 26, 1936, to March 10, 1937.

of the *sticticus* eggs hatched during this period. These percentages were determined by draining, drying, and reflooding the samples after May 1. In April, rising temperatures ended the winter dormant period of eggs in nature, and soil samples taken from the egg beds late in the month produced 100 percent hatches in the first flooding.

These results were confirmed by observations made in one instance in nature, where accumulated rainwater stood over a heavily infested egg-bed from January until the latter part of April. During this time an estimated 1 percent of the eggs hatched. This small hatch under these conditions may have been due to insufficient reduction of the oxygen in the water or to continued dormancy of the eggs. Areas flooded in nature at this time produced hatches of 100 percent.

Distribution.—Studies of the distribution of the eggs of these species in the Columbia River Valley have been made by taking 2-quart soil samples from many areas. Large variations in the numbers of eggs

found in contiguous areas frequently occur, and these variations must be considered to avoid serious error when this method of sampling is used. This variation was studied on several small uniform plots in different breeding areas. The current season's growth of weeds and grass was the only vegetation on these plots. Each plot was divided into 25 divisions and a 6 by 6 inch sample was taken from the center of each of the divisions. The number of larvae that hatched from samples taken within 2 feet of each other ranged from 0 to 139. The variable distribution of eggs obtained in three typical plots is shown in figure 2.

The zero point on the Willamette River gage at Portland is 1.15 feet above sea level. The normal Columbia River level is about 5 feet on this gage, and during the period from 1939 to 1947 the maximum

Plot 1
Divisions: 2' x 4'

0	139	1	12	2
0	118	0	0	2
0	10	12	0	17
57	35	112	19	1
1	7	2	0	31

Total – 578 larvae
Average – 23.1

Plot 2
Divisions: 4' x 4'

0	0	0	1	1
0	0	0	6	1
0	0	0	0	0
0	0	12	0	0
0	0	4	8	0

Total – 33 larvae
Average – 1.3

Plot 3
Divisions: 3' x 3'

0	2	0	2	0
1	33	4	8	3
0	16	5	41	8
0	25	4	0	4
0	2	14	72	17

Total – 261 larvae
Average – 10.4

FIG. 2. Variations in number of larvae of floodwater *Aedes* obtained from 6 by 6 inch soil samples taken from plots adjacent to the Columbia River.

height has been 24.8 feet. Eggs of *Aedes vexans* and *A. sticticus* have been found on all levels flooded by the river between its 8-foot and 25-foot stages. Relatively small numbers of eggs are present below the 10-foot level, probably because of the annual spring floods of the river. These floods recede slowly and the levels below 10 feet are not exposed and sufficiently dried until in the fall when the mosquitoes have been greatly reduced in numbers. Therefore the bulk of the eggs of these species are laid on ground flooded between the 10- and 20-foot levels of the river. Relatively few eggs are laid above the 20-foot level.

The extremely high flood crest of 30.5 feet at Vancouver in June, 1948, inundated large areas that are not normally flooded. A survey extending 70 miles downstream along the banks of the Columbia River showed that these flooded areas contained few mosquito eggs. Larvae were found in small numbers in a few areas only. These were all in creek bottoms except in one instance. The predominating species were *Aedes sticticus* and *A. cinereus*.

The eggs of *Aedes vexans* and *A. sticticus* are laid in various places. They have been found in moss growing on trees, logs, and concrete abutments, and also on rotten logs. Ten out of 30 samples of moss produced larvae when flooded, and 3 out of 5 samples of rotten wood

contained viable eggs. All of these samples were taken within 2 feet of the ground. The eggs may have been deposited after the flood waters had completely receded or while the water was still close to the height at which the eggs were laid. Samples taken at higher elevations were negative. Eggs of both species were found in these materials, but *vexans* eggs predominated.

Within the levels flooded by the rise of the rivers, more eggs were found in swales, pot holes, and gullies than on level ground and ridges. Ground of a loam texture with either dead or live vegetation, or both, is preferred to bare areas exposed directly to the sun and wind. Eggs are not found on bare sandy soil where there is little or no covering of vegetation and humus.

Fig. 3. Typical wooded area in the lower Columbia River Valley where large numbers of *Aedes vexans* and *A. sticticus* eggs are laid.

The numbers of eggs in open areas that were grazed or had a normal growth of grass and weeds, and in adjoining patches of woods with varying amounts of trees and brush, were obtained from a series of soil samples taken between the 8- and 16-foot river levels. It was estimated that the wooded areas of the type shown in figure 3 comprised 12 percent and the open areas 88 percent of the total area. The wooded sections contained 84 percent of the eggs per unit area and the open sections 16 percent. Because of the greater extent of open area, the total number of eggs in the two types of areas was approximately equal.

Clearing breeding areas of brush, fallen logs, and debris was done originally to facilitate the movement of control crews and the application of larvicides, but these clearing operations have partially or completely

stopped mosquito egg deposition. However, unless these operations are maintained by grazing or by reclearing at intervals of two or three years, the areas are soon covered with brush and vegetation and become infested.

The maximum height of the flood crest of the rivers depends upon the snowfall several hundred miles upstream and varies from year to year. Crests of 20 to 24 feet occur every few years. Frequently these crests are followed by a series of years of low water; so that eggs of *Aedes vexans* and *A. sticticus* which are laid at higher levels may not be flooded for several years. The percentage of eggs that survive during such periods determines the size of the mosquito population when the next highwater flood occurs.

Survival in nature.—Data on the length of time that *Aedes vexans* and *A. sticticus* eggs survive in nature were obtained by Gjullin and Yates (1946). Top soil containing large numbers of eggs was transferred from a willow swale to nearby higher ground above the flood level of the river. The topsoil in a cage 2 feet high and enclosing 208 square feet of ground was removed to a depth of 2 inches. A ½-inch mesh screen was laid down on the ground and a 16-mesh screen was used for the sides and the removable roof section of the cage. The soil containing the eggs was well mixed and placed in the cage to a depth of 3 to 4 inches. The screen at the bottom of the cage prevented moles from burrowing up through the soil containing the eggs, and the 16-mesh screen prevented mosquitoes from laying additional eggs on the soil after it had been placed in the cage.

Twelve samples of soil from this cage were brought to the laboratory and flooded in June and September of each year. Half the samples were flooded at once, and half were left at room temperature for 7 days before they were flooded. After the larvae had been counted, the samples were dried and reflooded until no further hatching occurred. The percentage of each species present in each sample was determined on the basis of 20 larvae taken at random from the sample. The total yearly hatch of each species is shown in Table I.

A continuous decline in the average hatch per sample of both *Aedes vexans* and *A. sticticus* eggs occurred from 1935 to 1937. The decline in the numbers of viable *vexans* eggs continued in 1938, but there was a sharp rise in the number of viable *sticticus* eggs. In 1937 a hole was torn in the cage, accidentally, and when the cage was visited again in June 1938, many mosquitoes were on the wing. Females of *A. sticticus* had apparently entered the cage through the opening and laid additional eggs. Data on *sticticus* eggs from samples taken in the cage from 1938 through 1941 are therefore based on eggs laid by the females which entered the cage in 1937.

A similar experiment was initiated in July 1944. Soil containing eggs of these species laid after July 1943 was placed in a second cage in another location in 1944. Twelve samples of this soil were flooded in July of each year. Large numbers of eggs were present in this soil for two years, but very few were found in the third year. The total yearly hatches for 1944, 1945, and 1946 were 8,241, 8,925, and 1, respectively, for *Aedes vexans*, and 9,299, 7,231, and 4 for *A. sticticus*.

These tests indicate that eggs of both species will survive in large

numbers for two or three years and that small numbers of eggs may survive for four years.

Effect of drying on viability.—The effect of drying on the viability of *Aedes vexans* and *A. sticticus* eggs was studied by Yates (1945). Top soil containing eggs of these species and 36 percent of moisture when it was collected was stored in a dry basement room. It was thoroughly mixed at intervals during the year, and 1-quart samples were tested for hatching and for moisture content. The numbers of

TABLE I

TOTAL NUMBER OF *Aedes vexans* and *A. sticticus* LARVAE HATCHING FROM 12 SAMPLES OF SOIL TAKEN IN JUNE AND SEPTEMBER OF EACH YEAR FROM A CAGE ESTABLISHED IN MAY, 1935

YEAR	SAMPLES FLOODED IMMEDIATELY		SAMPLES DRIED BEFORE FLOODING	
	June	September	June	September
Aedes vexans				
1935............	1,052	787	1,305	936
1936............	1,132	184	1,531	174
1937............	205	33	518	222
1938............	11	7	0	18
1939............	6	0	6	3
1940............	0	0	0	0
Total.......	2,406	1,011	3,360	1,353
Aedes sticticus				
1935............	1,442	101	655	267
1936............	31	28	100	23
1937............	7	3	20	23
1938............	701	126	449	187
1939............	951	347	706	265
1940............	76	6	47	8
1941............	4	0	1	0
Total.......	3,212	611	1,978	773

viable eggs were gradually reduced as the soil dried out, and none remained after 9 months, when the moisture content of the soil had fallen to 2 percent.

Effect of placing egg-free soil over soil samples containing eggs.—The effect of placing layers of egg-free soil of varying thickness over soil samples containing eggs was studied in the laboratory. These samples were compared with similar samples that had not been covered. Only 4 percent each of the eggs of *Aedes vexans* and 4 percent of those of *A. sticticus* hatched in samples covered with ½ inch of soil. In samples covered with ¼ inch of soil 53 percent of the *vexans* and 46 percent of

the *sticticus* eggs hatched.   Apparently no hatching occurred when eggs were covered with an inch or more of soil.   Samples 2 or 3 inches deep that were flooded several times until there was no further hatching produced large hatches when they were turned over.   Loose soil and debris which might accumulate over eggs in nature probably would not prevent them from hatching, since the material would be light and have a tendency to float when flooded.

Predators.—Several species of Coleoptera have been shown by Stage and Yates (1939) to be predaceous on *Aedes* mosquito eggs laid in the areas flooded by the Columbia River and in mosquito-breeding areas in the Cascade Mountains.   The beetles from these areas were gathered and placed in the laboratory in jars containing soil, humus, and leaves. Pill boxes containing eggs were placed under the leaves.   The following carabids destroyed 8 to 15 eggs per individual per week: *Trechus chalybeus* Dej., *Agonum pusillum* (Lec.), *Pterostichus algidus* Lec., and *Bembidion* sp.   Several other species of this family destroyed 2 to 6 eggs per individual per week while others did not destroy any.   Species of beetles from the families Endomychidae, Staphylinidae, and Dytiscidae were not predaceous on the eggs.

AQUATIC STAGES

Time and conditions required for development.—The time required for development of the aquatic stages varies with temperature and food conditions of the water.   In the laboratory, at a constant temperature of 80° F., both *Aedes vexans* and *A. sticticus* larvae reached the fourth instar in 3 days, began pupating on the fifth day, and completed pupation on the sixth day.   In nature, development requires 10 days to 3 weeks, depending on temperature.   Larvae that have pupated in cold and rainy weather have remained in the pupal stage for as long as a week.   A few hours of clear weather and a slight rise in temperature have then caused complete emergence in a short time.

The waters in which the larvae develop in this region are nearly neutral.   Over a three-year period a series of pH determinations of water from breeding areas ranged from 6.4 to 7.3.   The average for all determinations was 7.1.

When waters in swales and gullies rise to 4 feet or more, most of the larvae migrate or are carried by currents or wave action to the margins or to other shallow areas where the water is warmer and contains more food.   In a swale where the water was rising rapidly, a group of larvae were observed wiggling steadily toward shallower water at the rate of 2½ feet per minute.

Predators.—Predaceous insects destroy a few *Aedes vexans* and *A. sticticus* larvae and pupae, but usually they are of little importance as a control measure.   However, laboratory experiments in which a number of local predaceous insects were fed mosquito larvae showed that many larvae could be destroyed if predators were numerous.

Other predators that were observed attacking the larvae of these species were chironomid larvae of the genus *Palpomyia*.   These larvae penetrated the unchitinized portion between the eighth segment and the air tube and sucked the liquid from the body of the larvae.   A flatworm, *Palmaria maculata*, attached itself in various places on the larvae and destroyed one or two larvae a day.

Attempts to establish colonies of the top minnow, *Gambusia patruelis* Baird and Girard, in permanent ponds in the lower Columbia River flood plain have not been successful.   The spring rises of the river

TABLE II

SEASONAL ABUNDANCE OF MOSQUITOES, ESPECIALLY *Aedex vexans* AND *A. sticticus*, AS SHOWN BY COLLECTIONS IN A NEW JERSEY TYPE LIGHT TRAP

YEAR	MONTH	DAYS OPER-ATED	AVERAGE DAILY CATCH			MAXIMUM HEIGHT OF FLOOD CREST	
			A. vexans	*A. sticticus*	All Species	Height (feet)	Date
1932	July.......	15	10.7	5	26	20.6	May 25
	August.....	21	2.5	0.4	10.3		
1934	July.......	6	0.17	0.17	1.2	16.5	May 9
	August.....	16	0.6	0.5	4.1		
1938	June	8	62	31	149	20.8	June 9
	July.......	25	46.5	27.5	128		
	August.....	29	1.6	5.1	13.5		
	September.	28	0.1	0.4	5.5		
1939	June.......	15	1.7	0.3	19	13.9	May 22
	July.......	30	4.1	0.7	18		
	August.....	27	1.5	0.2	23		
	September.	28	0	0	6.4		
1940	July.......	24	6.5	0.6	28	12.8	June 6
	August.....	26	1.6	0.1	26		
	September.	12	8	0	26		
1941	June.......	28	0	0	2.6	9.6	May 11
	July.......	30	0.3	0	8		
	August.....	26	0.04	0	7.2		
1942	July.......	25	12.5	4.1	27	16.5	May 30
	August.....	30	10	2.3	27		
	September.	30	0.7	0	13.5		
	October....	9	0.1	0	4.7		
1944	June.......	26	0.5	0.04	2	11.2	June 20
	July.......	31	5.5	0.2	8		
	August.....	31	2.3	0.2	3		
1945	July.......	20	54	18	84	18.1	June 10
	August.....	29	26	6	41		
	September.	5	1.6	0	7.2		
1946	July.......	22	43	1.5	74	20.8	May 31
	August.....	15	8	1.3	22		
	September.	7	1.4	0.14	10.4		

flooded the ponds and scattered the minnows so that many of them were destroyed by predaceous fish. When the flood waters receded, the predaceous fish left in the ponds soon destroyed the minnows that

remained. *Gambusia* are of some value for controlling *Anopheles*, *Culex*, and *Culiseta* mosquitoes under conditions found in this area, but are of little or no value for controlling *Aedes vexans* and *A. sticticus*.

ADULTS

Light-trap collections.—A New Jersey type light trap was operated in a mosquito-breeding area near Portland in 1932 and 1934 and from 1938 to 1946. The collection data are given in Table II. Some control work was carried on during all these years except in 1938. This year is therefore typical of the numbers of these mosquitoes that develop when the river flood stage reaches 20 feet. The relatively
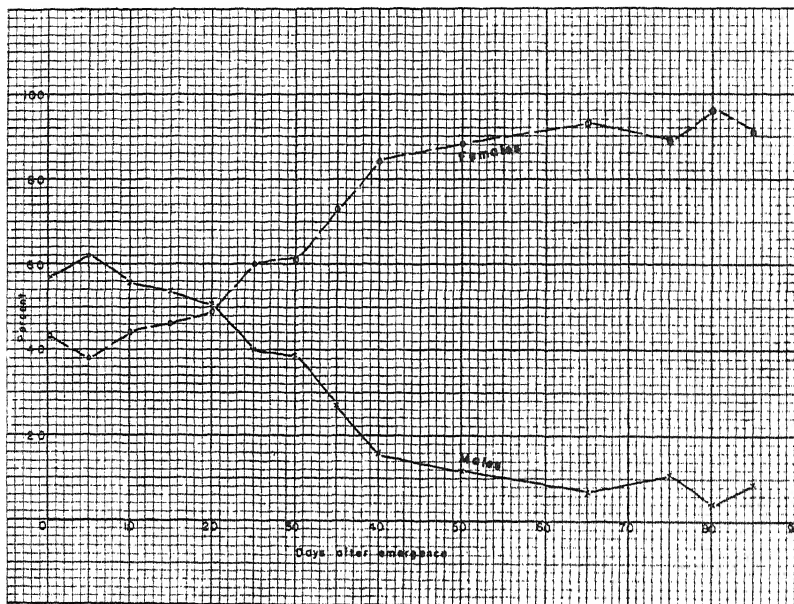
FIG. 4. Seasonal variation in the sex ratio of a mixture of *Aedes vexans* and *A. sticticus* adults taken in net collections.

small populations of these species that develop when the crest of the flood stage is low is indicated by the records for 1941 and 1944 when the maximum height was 9 and 11 feet respectively.

Seasonal variation of sex ratios.—Information on seasonal variation of sex ratios was obtained in a study of 14,944 adults taken in net collections in three breeding areas. The mosquitoes were not separated as to species, and the figures given represent a mixture of *Aedes vexans* and *A. sticticus*. A continued increase in the ratio of males to females was observed for several days after the last emergence in these areas. This increase was apparently due to a rapid dispersion of the females. Males continued to be more numerous than females in these and nearby areas for about 20 days and then became less numerous. This change in the ratio was caused by the greater longevity of the females. The

average seasonal variation in the ratio of males and females is shown in figure 4.

Range and height of flight.—General observations have indicated that the maximum flight range of these species may be 25 to 30 miles. Stage *et al.* (1937) recovered an *Aedes vexans* female 3 miles from the point where it was stained, and several *A. sticticus* females 5 miles from the point of staining.

A limited amount of information on the height at which *Aedes vexans* and *A. sticticus* mosquitoes fly was obtained in two different areas along the Columbia River. The population of these species at ground level and at 20 and 30 feet above ground level in trees was compared on the basis of ten minute collections of females. The collections were made on the collector's clothing with a chloroform tube. *A. vexans* was annoying at ground level, but it was not found at the 20- and 30-foot levels. *A. sticticus* was about one-third as numerous at the 20- and 30-foot levels as it was on the ground.

Longevity.—Few females of *Aedes vexans* lived more than 100 days in this region and the maximum age of males was about 90 days. The maximum age for *sticticus* females was about 94 days and for males about 65 days. *A. vexans* females have lived 78 days in laboratory cages.

Night-biting habits.—Information on the night-biting habits of *Aedes vexans* and *A. sticticus* was obtained in ten-minute collections made at hourly intervals by two men on the nights of July 24 and August 7, 1933. These collections were also made with chloroform tubes. The average number of mosquitoes taken ranged from 20 to 61. The largest number taken at one time was 98 in the July collection at 7 p.m. The smallest average number of the two species was taken at 3 a.m. During the hours of daylight and partial daylight from 6 to 8 a.m., the catch consisted of 42 percent *vexans* and 54 percent *sticticus*. During the hours of complete darkness from 9 p.m. to 4 a.m., 69 percent *vexans* and 31 percent *sticticus* were taken. In eight daylight collections in this same area from July 8 to August 15, 42 percent *vexans* and 58 percent *sticticus* were taken. It is apparent that *sticticus* bites considerably less at night than in the daytime and that there is little change in the biting rate of *vexans*. The reduction in the biting rate of *sticticus* at night may be due either to darkness or to lower temperatures. The results of night tests are given in Table III.

Color preference.—The relation between clothing colors and biting rate of *Aedes sticticus* was studied by Gjullin (1947). He found that this species preferred black, blue, red, brown, green, yellow, and white in the order named. Black was almost three times as attractive as white, and more than twice as attractive as yellow to this species. The color preferences of *sticticus* followed the same sequence as the spectral reflectance values of the test colors in a wave-length range of 254 to 750 millimicrons. This correlation suggests that this species lacks the ability to distinguish colors, and that colors are chosen on the basis of their spectral reflectances.

Egg laying.—Matings of both *Aedes vexans* and *A. sticticus* adults and the production of viable *Aedes sticticus* eggs were obtained in a 34 by 34 by 36 inch cage in which the two species were confined in the

laboratory. The temperature was kept at 72° F. and the humidity at 70 percent. Light supplied by one window in the rearing room was supplemented at times by two 200-watt shaded ceiling lights. Females were given blood meals on a rabbit, and males were fed raisins and sugar solutions. Additional mosquitoes reared from soil were added from time to time to maintain a colony of approximately 200 females. Approximately 1,900 *sticticus* eggs were laid by this colony in the month of March, of which about 78 percent were viable. Few *vexans* eggs were laid, and only a small percentage were viable.

TABLE III

AVERAGE NUMBER OF *Aedes vexans* AND *A. sticticus* MOSQUITOES[1] COLLECTED IN 10 MINUTES AT HOURLY INTERVALS ON JULY 24 AND AUGUST 7, 1933

TIME TAKEN	TEMPERATURE °F.	AVERAGE NUMBER TAKEN	
		A. vexans	*A. sticticus*
6 p. m.	75–78	24	29
7	72–72	21	37
8	70–70	25.5	19
9	67–68	18	8
10	64–65	17	6
11	61–65	22	11
12	59–65	13	9
1 a. m.	58–60	19.5	11
2	56–58	17	5
3	56–58	15	4
4	55–57	16	7.5
4:45	55–57	14	15.5

[1]Thirty-three *Aedes cinereus* Meig., 11 *A. varipalpus* Coq., 4 *Anopheles punctipennis* Say., 1 *Culex pipiens* L., and 13 *C. tarsalis* Coq. were also taken in these collections.

In the course of a month approximately 700 *Aedes sticticus* eggs were laid by 75 females confined in a metal cylinder 9 inches high and 10 inches in diameter, which was placed on end and covered with cheese cloth. The eggs were deposited on moist cellucotton, which was placed in dishes in the cages. Many viable eggs were also obtained from a colony of 30 females and an equal number of males when they were confined in this type of cage and fed citrated beef blood to which 12 per cent of cane sugar had been added. The mosquitoes were fed by placing pieces of cellucotton dipped in blood on the cheesecloth top of the cage. Males also fed on the sweetened blood.

Aedes vexans and *A. sticticus* females which have mated in nature readily lay eggs in laboratory cages if given blood meals. The average number of eggs laid by 214 *vexans* under these conditions was 43, and the largest number laid by one female was 144. The largest number laid by a *sticticus* female was 96, and the average number laid by 52 females was 22. Caged adults usually lay eggs from 5 to 10 days after they have been given a blood meal. No records are available of

any *sticticus* laying more than one batch of eggs, but several *vexans* have laid from two to four batches.

Blood meals were readily taken by virgin *Aedes vexans* and *A. sticticus* females that were reared from eggs in the laboratory. The virgin females of *vexans* laid from one to four batches of eggs when blood meals were given subsequent to the laying of each lot of eggs. They averaged 27 eggs per batch. Embryos did not develop in these eggs and none of the eggs hatched. No eggs were laid by the virgin *sticticus* females.

SUMMARY

The annual spring floods of the Columbia River usually inundate thousands of acres of open and wooded lowlands along its borders. These flooded lowlands serve as ideal breeding places for the flood-water mosquitoes, *Aedes vexans* (Meig.) and *Aedes sticticus* (Meig.). During a period of 18 years a quantity of ecological and biological data was accumulated.

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OBITUARY NOTICE

PAUL E. TELFORD passed away at Culver City, California, on January 29, 1950, due to a heart condition. Born at Idaho Falls, Idaho, May 12, 1922, he completed his primary and secondary education in this city. He attended Utah State Agricultural College, receiving the B. S. degree in Entomology in June, 1946. Following this he continued his study of entomology at Ohio State University, receiving his M. S. degree in 1948. He married Alice Gailey of Kaysville, Utah, in 1945 and they had a son, John Wm. Telford, now three years old. Paul worked on bee loss investigations for the Utah Agricultural Experiment Station during the summer of 1944 and 1945, and the U. S. Public Health Service in 1946, in Utah. His field of particular interest was mite taxonomy and collecting bird parasites. Just before his death he was planning further graduate study in entomology in southern California.—G. F. Knowlton.

BOOK NOTICES

PRINCIPLES OF ANIMAL ECOLOGY, by W. C. Allee, A. E. Emerson, O. Park, T. Park, and K. P. Schmidt. Philadelphia, W. B. Saunders Company. ix+837 pp. 1949. Price, $14.00.

There has been no very good book on the principles of ecology since Elton's *Animal Ecology*; and any new book in the area, particularly one by the five distinguished ecologists of the Chicago Group, would be awaited with anticipation and welcomed. The new volume is no such direct statement as Elton's, but is a treatise of a half-million words. Perhaps the publishers got more than they bargained for in a new text, and outsiders might be forgiven for raising eyebrows at the idea that it takes 800 pages to set forth the principles of ecology. Ecology is a widespread approach in biology, entering most fields, but it may not be so large a field as that would imply. The principles of ecology are in the book, however, along with a wealth of illustrative and supporting material. Whether judged by size or scholarship, *Principles of Animal Ecology* is quite a book.

The first section is a history of ecology, about seventy pages of compressed but detailed discussion of the development of the field. While hardly light reading, it is a valuable reference section, packed with an amount of material such as is at the command of few men in the field. In the second section factors of environment are analyzed. The various physical and chemical aspects of environment are first treated, each about as thoroughly as is readable within the limitations of a single book. Most of these chapters contain some discussion of physical and chemical background to make easier their use without other references; and the important point is made through the section that these factors do not act in isolation, and that study of one apart from others may lead to error. The last chapter of the section deals more briefly with biotic factors of the environment—microclimatic effects of vegetation, food relations, and symbiosis.

For the third section on populations the authors have pooled information from human population science, laboratory and field population study, and mathematical analysis of theory in a most valuable synthesis, well in advance of anything else now available to ecologists. The section does not contain any extended development of the mathematics of populations, which would be valuable, if not much appreciated by some readers, but has adequate discussion of many aspects of population problems. If it leaves open many questions of populations in natural communities, it is only because answers are not to be had at this point. The chapters on animal aggregations and insect societies summarize ideas in these fields, in which two of the authors are well known for their work. The following section on the community treats various aspects of community organization—stratification, metabolism, periodism, and succession. The discussions of stratification and periodism are excellent, and that on metabolism of communities may well be selected for special praise as the best treatment available of a direction in which the field will be advancing. Major plant-animal communities of the earth are described in the chapter on biomes and biome-types, the latter being a useful new concept to describe the convergent communities of different continents (e. g. deciduous forest biomes of North America, Europe, and Asia).

The last section treats ecology and evolution and is an ambitious blending of these fields and genetics. The union is successful and the discussion a good one for the most part. The final chapter, however, is an attempt to treat "Evolution of Interspecies Integration and the Ecosystem" and to show how evolution of communities as organized units is possible. It is in this chapter that the book most conspicuously falls short of its aims, for the authors can only select some examples of mutual adaptation and speculate on "the possibility that interspecies associations evolve as supraorganismic units." Species in a natural community are interrelated through a most complex web of life, and it is only in the minority of cases that a species is so closely dependent on another single species or combination of species throughout its range that it is likely to evolve in conjunction with other species as such. True as it is that organisms must evolve in adaptation to their biotic environment, there is no evidence that, except in some symbiotic relations, evolution in "units" of more than one species occurs. There is, in fact, good evidence that, with some exceptions including symbiotes, community units above the species level as bounded and organized entities do not exist. This

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ecologist, while regarding the community as a system of interacting populations, dissents from any assumption of undemonstrated and unlikely supraorganismic unity. Moreover, the definition of a major community as "a natural assemblage of organisms which, together with its habitat, has reached a survival level such that it is relatively independent of adjacent assemblages of equal rank; to this extent, given radiant energy, it is self-sustaining," is not a very useful, operational definition.

Principles of Animal Ecology is a well-written book, free from the jargon-juggling for which some of the profession have been noted. This does not mean that in vocabulary or content it is designed for the average sophomore. It is perhaps too large and advanced a book to serve well as a text for lower-level courses. But the book will be a standard reference in ecology in the future, and the most valuable single reference work in the field. Its publication is a major contribution to ecology, but the value of the book may be expected to extend far beyond the profession. It brings together in useful form much of the voluminous, widely dispersed literature of ecology. It provides a comprehensive and authoritative reference in which entomologists, taxonomists, and the many other biologists who deal with some phase of ecology can find information on their ecological problems and others' work with comparable problems.

R. H. WHITTAKER.

NOTES ON SOME JAPANESE ENTOMOLOGICAL PUBLICATIONS—The recently established Shikoku Entomological Society has published the first issue of its new organ, "Transactions of the Shikoku Entomological Society," which will appear semi-annually. The sixteen pages of Volume I, Number 1, are devoted exclusively to a paper by Michio Chujo and Yoshihiko Kurosawa on "The Buprestidae of Shikoku, Japan (Coleoptera)." Forty-seven species are treated. The use of English for the title, sub-headings, distribution and host plant data, and cited literature permits the use of the material by readers outside Japan. The editor is Dr. Tamotsu Ishihara who can be addressed c/o the Entomological Laboratory, Matsuyama Agricultural University, Narami-cho, Matsuyama-shi, Shikoku, Japan.

The first post war issue of the "Transactions of the Kansai Entomological Society" appeared in November, 1949 (Volume XIV, Part 2). Publication had been suspended following the release of Volume XIV, Part 1, in February, 1944. The table of contents and majority of papers are presented in English. Articles in the November, 1949 issue cover a variety of subjects. Syoziro Asahina treats 23 species in "Odonata in Sachalin." Kichizo Takeuchi, well known as the editor of the entomological journal "Tenthredo," contributed "List of the Food-plants of Japanese Sawflies." The longest article, by Masaaki Tokunaga and Syoiti Kadowaki is "Studies on the Life History and Bionomics of *Phyllotreta vittata* Fabricius." In a note on page 6, the editorial committee expresses the desire to share its information with foreign workers and to learn of entomological developments outside Japan. The managing editor is Nobuyoshi Tosawa who recently severed his connection with the Takarazuka Insect Museum. He may be addressed at Shibakawa, Kotoen, Nishinomiya, Hyogo-Ken, Japan.

"Tenthredo", formerly issued by the Takeuchi Entomological Laboratory, has not resumed publication. The Kansai Entomological Society now includes Mr. Kichizo Takeuchi on its editorial committee and proposes to issue "Tenthredo" irregularly as finances permit.

"Shin Konchu" (New Entomology) is appearing the most regularly of any Japanese entomological journal. The Entomological Society of Japan, which suspended publication of "Konchu" in August, 1944, has cooperated with the Applied Entomological Society and the Hygienic Entomological Society in sponsoring the new periodical. Twenty-three issues have appeared since publication started in April, 1948. The most recent issue is Volume III, Number 3, March, 1950. Text is entirely in Japanese. The present editor is Dr. Hiroharu Yuasa, National Agricultural Experiment Station, Nishigaharamachi, Takinogawa-Ku, Tokyo, Japan.

DON J. PLETSCH.

THE ENTOMOLOGICAL SOCIETY OF AMERICA
LIST OF MEMBERS

(MAY, 1950)

In this list, which is arranged alphabetically, members are given in lower case type, Fellows in small capitals, and Honorary Fellows in capitals. The year of admission to membership is given before the name, and of election to Fellowship and Honorary Fellowship in parentheses following the address. Names of Life Members are indicated by asterisk (*) and the special field of work in italics. Ch. indicates Charter Member, 1906.

'39. Aamodt, T. L., State Entomologist's Office, University Farm, St. Paul, Minn.

'47. Abdel-Malek, Albert, Department of Entomology, Faculty of Science, Fouad I Univ., Abbassia, Cairo, Egypt.

'40. Ahrens, Carsten, 3461 Harrisburg Street, Pittsburgh 4, Penn. *Odonata.*

'10. ALEXANDER, CHARLES P., Massachusetts State College, Amherst, Mass. (F. '20). *Tipulidae.*

'33. Alexander, Gordon, Department of Biology, University of Colorado, Boulder, Colo. *Orthoptera.*

'25. ALLEN, H. W., Box 150, Moorestown, N. J. (F. '40). *Tiphiidae, Tachinidae.*

'42. Allen, Theodore, 1125 Logan Street, Muscatine, Iowa.

'49. Alrutz, Robert W., 304 Harker Hall, University of Illinois, Urbana, Ill.

'32. Amos, John M., Virginia Polytechnic Institute, Extension Service, Blacksburg, Va. *Coccidae, Cerambycidae.*

'29. Anderson, Lauren D., Citrus Experiment Station, Riverside, Calif. *Gerridae.*

'47. Anderson, M. L., Virginia Smelting Co., West Norfolk, Va.

'37. Anderson, William H., Room 429, U. S. National Museum, Washington 25, D. C. *Coleopterous larvae.*

'39. ANDRE, FLOYD, Iowa State College, Ames, Iowa. (F. '47). *Thysanoptera.*

'28. App, Bernard A., 1561 Kenmore Road, Columbus 11, Ohio. *Economic Entomology.*

'40. Archer, Allan F., Museum of Natural History, University, Ala. *Arachnida.*

'23. Armstrong, Thomas, Dominion Entomological Laboratory, Vineland Station, Ontario, Canada. *Scarabaeidae.*

'49. Arnett, Ross H., U. S. National Museum, Division of Insects, Washington 25, D. C.

'36. Ashton, Donald F., 2711 Van Dyke Avenue, Raleigh, N. C. *Culicidae.*

'37. Assmuth, Rev. Joseph, Fordham University, New York 58, N. Y. *Isoptera.*

'42. Atkins, E. Laurence, Jr., University of California, Citrus Experiment Station, Division of Entomology, Riverside, Calif.

'49. Auerbach, Stanley I., Department of Zoology, Northwestern University, Evanston, Ill. *Centipedes, Chilopods.*

'37. Babers, Frank H., De Neane Drive, Hillendale, Silver Spring, Md. *Physiology.*

Ch. *BACK, E. A., Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '38). *Asilidae, Aleyrodidae.*

'49. Back, Richard C., Department of Entomology, Cornell University, Ithaca, N. Y.

'21. BAERG, W. J., University of Arkansas, Fayetteville, Ark. (F. '32). *Poisonous Arthropods.*

'30. *Bailey, J. W., 27 Willway Road, Richmond, Va. *Myriapoda.*

'47. Bailey, Norman S., 16 Neponset Avenue, Hyde Park 36, Mass. *Tabanidae, Tingidae.*

'11. BAKER, A. C., Apartado Number 3, Colonia Anahuac, D. F., Mexico. (F. '29). *Aphididae, Aleyrodidae.*

'12. Baker, A. W., Ontario Agricultural College, Guelph, Ontario, Canada.

'22.   Baker, Howard, Bureau of Entomology and Plant Quarantine, Washington 25, D. C.   *Apple and Pecan Insects.*
'36.   Baker, Walter C., P. O. Box 242, Garden City, N. Y.   *Toxicology.*
'28.   BALCH, R. E., Dominion Entomological Laboratory, Fredericton, New Brunswick, Canada.   (F. '44).   *Forest Insects.*
'20.   BALDUF, W. V., 308 Entomology Building, University of Illinois, Urbana, Ill.   (F. '40).   *Entomophagous Insects.*
'38.   Ballou, Charles H., Division de Entomologia, Maracay, Edo, Aragua, Venezuela.   *Economic Entomology.*
'43.   Balock, John W., P. O. Box 2280, Honolulu 4, T. Hawaii.
'08.   BANKS, NATHAN, 103 Norfolk Street, Holliston, Mass. (F. '14, H. F. '45).
Ch.   BARBER, H. G., 143 East Third Avenue, Roselle, N. J. (F. '30). *Hemiptera, Lygaeidae.*
Ch.   BARBER, H. S., U. S. National Museum, Washington 25, D. C. (F.'28). *Coleoptera.*
'23.   Bare, Clarence O., Box 7062, Richmond 21, Va.   *Notonectidae.*
'26.   BARNES, H. F., Rothamsted Experimental Station, Harpenden, Herts., England.   (F. '37).   *Cecidomyiidae.*
'49.   Barnes, John Warren, Div. of Entomology, University Farm. University of Minnesota, St. Paul 1, Minn.
'43.   Barnes, Ralph C., U. S. P. H. S., 605 Volunteer Bldg., Atlanta, Ga. *Culicidae.*
'40.   Barnett, Capt. Herbert C., 0-56236, 406th Medical General Laboratory, APO 500, c/o P. M., San Francisco, Calif.
'47.   Barr, William F., Division of Entomology, University of California, Berkeley 4, Calif.   *Buprestidae, Cleridae.*
'39.   Barrett, John P., c/o Armour and Company, Department of Chemical Research, Union Stock Yards, Chicago 9, Ill.   *Calliphoridae.*
'41.   Barrett, Paul H., 441 W. 2nd Street, Apt. 404, Lexington, Ky. *Aquatic Insects.*
'35.   Barrett, W. L., Jr., 229 Rosemont Drive, San Antonio, Texas. *Diptera, Ectoparasites.*
'46.   Barro, Manuel, Calle 12 #220, Vedado, Habana, Cuba.
'46.   Bartholomai, C. W., P. O. Box 242, Garden City, N. Y.
'49.   Batchelor, Gordon Stanley, P. O. Box 175, College Station, Pullman, Wash.
'31.   BATES, MARSTON, Rockefeller Foundation, 49 W. 49th St., New York 20, N. Y.   (F. '40).   *Diptera, Trypetidae.*
'24.   BEAMER, RAYMOND H., 1000 Missouri Street, Lawrence, Kansas.   (F. '34). *Homoptera, Cicadellidae.*
'46.   Beatie, Russel H., Westvaco Chlorine Products Corp., 405 Lexington Avenue, New York 17, N. Y.
'34.   Beck, Elmer W., Corn Borer Laboratory, Ankeny, Iowa.   *Parasites European Corn Borer.*
'47.   Beck, Stanley D., Department of Economic Entomology, University of Wisconsin, Madison, Wis.
'49.   Becker, Edward C., Illinois Natural History Survey, Urbana, Ill. *Elateridae.*
'47.   Beckham, Clifford M., Georgia Agricultural Experiment Station, Experiment, Ga.
'43.   BEEBE, WILLIAM, New York Zoological Society, Zoological Park, Bronx Park, New York, N. Y.   (F. '44).
'42.   Belkin, John N., Division of Entomology, College of Agriculture, University of California, Los Angeles 24, Calif.   *Culicidae, Tabanidae.*
'25.   BELL, ERNEST L., 150-17 Roosevelt Avenue, Flushing, N. Y. (F. '40). *Hesperiidae.*
'49.   Bellinger, Peter F., 30 Homelands Terrace, New Haven, Conn. *Lepidoptera.*
'40.   Benesh, Bernard, Sunbright, Tennessee.   *Lucanidae.*
Ch.   Bentley, Gordon M., 141 W. Peachtree Street, Knoxville 15, Tenn. *Orthoptera.*
'23.   Benton, Curtis, 113 Sixteenth Street, N. W., Minot, N. D.
'17.   *BEQUAERT, JOSEPH C., Curator of Insects, Museum of Comparative Zoology, Cambridge, Mass.   (F. '34).   *Vespidae, Tabanidae.*
'49.   Berg, Clifford O., Department of Zoology, Ohio Wesleyan University, Delaware, Ohio.   *Life Histories of Diptera.*

'28. Berly, J. A., Division of Entomology, Clemson College, S. C. *Coccidae, Odonata.*

'43. Berner, Lewis, Department of Biology, University of Florida, Gainesville, Fla.

'39. Berry, Paul A., United States Embassy, Paris, France. *Biological Control.*

'34. Bess, Henry A., University of Hawaii, Honolulu, Hawaii. *Ecology, Forest Insects.*

Ch. BETTEN, CORNELIUS, 177 Woodland Rd., Asheville, N. C. (F. '37). *Trichoptera.*

'28. Bibby, F. F., Smithville, Miss. *Cicadidae.*

'47. Bick, George H., Department of Biology, Tulane University, New Orleans, La. *Odonata, Culicidae.*

'38. *Bickley, William E., Jr., Department of Entomology, University of Maryland, College Park, Md. *Chrysopidae.*

'25. Bigger, J. H., Natural Resources Building, Urbana, Ill. *Plant Resistance to Insect Attack.*

'30. Billings, Samuel C., 8434 Piney Branch Court, Silver Spring, Md. *Mothproofing.*

'13. BILSING, S. W., College Station, Texas. (F. '41). *Cerambycidae.*

Ch. BIRD, HENRY, 600 Milton Road, Rye, N. Y. (F. '30). *Noctuidae, Papaipema.*

'24. BISHOP, SHERMAN C., Department of Biology, University of Rochester, Rochester, N. Y. (F. '43). *Arachnida.*

Ch. BISHOPP, F. C., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '28). *Ixodoidea, Siphonaptera, Anopleura.*

'25. Bissell, Theodore L., Department of Entomology, University of Maryland, College Park, Md. *Aphididae, Curculionidae.*

'37. Blackburn, Norris D., Department of Zoology and Entomology, Pennsylvania State College, State College, Pa. *Chrysomelidae.*

'32. BLANTON, FRANKLIN S., P. O. Box 3391, Orlando, Fla. (F. '46). *Trypetidae, Otitidae.*

'30. Blauvelt, Helen Hayden, c/o William Savey, Lake Road, Ithaca, N. Y.

'29. BOESEL, M. W., R. R. #2, Oxford, Ohio. (F. '43). *Heleidae Tendipedidae, (Chironomidae).*

'44. Bohart, George Edward, Box 80, U. S. A. C., Logan, Utah.

'37. BOHART, RICHARD M., Division of Entomology, College of Agriculture, Davis, Calif. (F. '47). *Strepsiptera, Vespidae.*

'46. Bonhag, Philip F., Asst. Prof. of Entomology, Kansas State College, Manhattan, Kans. *Diptera.*

'28. BORROR, DONALD J., Department of Zoology, Ohio State University, Columbus 10, Ohio. (F. '43). *Odonata.*

'49. Boone, Peter, R. F. D. #3, Box 172, Greenhouse Drive, Princeton, N. J.

'46. Boudreaux, H. Bruce, Department of Zoology, Louisiana State University, Baton Rouge 3, La. *Aphididae.*

'14. BOVING, ADAM G., 221 Rock Creek Church Road, Washington 11, D. C. (F. '29, H. F. '41). *Coleopterous larvae.*

'33. Boyce, A. M., Citrus Experiment Station, Riverside, Calif.

'49. Boyle, W. Wayne, Department of Entomology, Cornell University, Ithaca, N. Y.

Ch. BRADLEY, J. C., Cornell University, Ithaca, N. Y. (F. '14). *Campsomeris, Vespidae, Scoliidae.*

'19. BRADLEY, G. H., Department of Public Health, Communicable Disease Center, Atlanta, Ga. (F. '41). *Diptera, Culicidae.*

'37. Bradley, William G., 2256 Collingwood Avenue, Toledo, Ohio. *Parasitic Hymenoptera.*

'23. Branch, Hazel E., University of Wichita, Wichita 6, Kansas. *Chironomidae larvae.*

'25. Brandhorst, Carl T., 106 Lincoln Street, Seward, Neb. *Wasps.*

Ch. BRAUN, ANNETTE F., R. R. #13, Box 41C, Cincinnati 30, Ohio. (F. '24). *Microlepidoptera, Trichoptera.*

'26. BREAKEY, E. P., Rt. 1, Box 430, Sumner, Wash. (F. '43). *Cicadellidae.*

'37. Breland, Osmond P., Department of Zoology, University of Texas, Austin, Texas. *Chalcidoidea, Culicidae.*

'29. Brindley, T. A., 822 East Eighth Street, Moscow, Idaho. *Pea Weevil.*

'26. Brittain, W. H., McDonald College, Quebec, P. Q., Canada. (F. '37). *Homoptera.*

'20. Bromley, Stanley W., Scofieldtown Road, Stamford, Conn. (F. '37). *Asilidae.*

'40. Brookman, Bernard, Hooper Foundation, University of California, Medical Center, San Francisco 22, Calif. *Diptera, Culicidae.*

'47. Brooks, George T., Biology Department, Southern University, Baton Rouge, La.

'39. Brower, Auburn E., 5 Hospital Street, Augusta, Maine. *Lepidoptera, Catocala.*

'33. Brown, F. Martin, Fountain Valley School, Colorado Springs, Colo. (F. '44). *Pieridae of the Americas.*

'42. Brown, John H., Administration Bldg., Department of Public Health, Edmonton, Alberta, Canada.

'26. Brown, W. J., Entomological Branch, Department of Agriculture, Ottawa, Ontario, Canada. (F. '40). *Coleoptera.*

'47. Bruce, Willis N., 128 Natural Resources Building, Urbana, Ill.

Ch. Brues, C. T., Biological Laboratory, Harvard University, Cambridge, Mass. (F. '14, H. F. '46). *Hymenoptera.*

'30. Bruner, S. C., Estación Agronómica, Santiago de las Vegas, Havana, Cuba. (F. '37). *Homoptera, Hemiptera of Cuba.*

'27. Brunson, Marvin Howard, Box 150, Moorestown, N. J.

'33. Bryant, Elizabeth B., Museum of Comparative Zoology, Cambridge 38, Mass. (F. '43). *Arachnida.*

'30. Bryant, Owen, Steamboat Springs, Colo. *Coccinellidae.*

'38. Bryce, P. I., Entomological Laboratory, Vineland Station, Ontario, Canada. *Fruit Tree Insects.*

'45. Buchanan, William Dwight, Forest Insect Laboratory, P. O. Box 244, Station G., Columbus 7, Ohio.

'47. Bucher, Gordon E., Biological Control Investigations Laboratory, c/o Dept. Bacteriology, Queens University, Kingston, Ontario, Canada. *Morphology, Physiology, Biological Control.*

'49. Buck, John B., National Institute of Health, Bethesda, Md.

'31. Bugbee, Robert E., Department of Biology, Allegheny College, Meadville, Pa. *Chalcidoidea.*

'38. Bunn, Lt. Col. Ralph W., 0-41762, 4th Med. Lab., APO 403, c/o P. M., New York, N. Y. *Fulgoridae, Curculionidae.*

'45. Buren, William F., Assistant Sanitarian (R), U. S. Public Health Service, P. O. Drawer 1246, Miami Beach, Fla.

'35. Burks, B. D., U. S. National Museum, Washington 25, D. C. (F. '44). *Chalcididae.*

'27. *Burrell, Robert W., P. O. Box 1291, Yakima, Wash.

'29. Bushey, Clinton J., Taylor University, Upland, Ind. *Curculio.*

'35. Bussart, J. Everett, 215 West Harrison Street, Wheaton, Ill. *Tachinid Biology.*

'30. Butt, F. H., Cornell University, Ithaca, N. Y. (F. '40). *Morphology, Embryology.*

'20. Buys, John L., Department of Biology, St. Lawrence University, Canton, N. Y. (F. '48). *Homoptera, Cicadellidae.*

'36. Buzicky, Albert W., 1709 Rome Avenue, St. Paul 5, Minn. *Chyphotes.*

'46. Byars, L. Freeland, 500 Park Ave., Apt. 8, East Orange, N. J. *Ecology of Ants.*

'24. Byers, C. Francis, Department of Biology, University of Florida, Gainesville, Fla. (F. '41). *Odonata.*

'35. *Caldwell, John S., 535 South Court Street, Circleville, Ohio. (F. '46). *Fulgoridae, Psyllidae.*

'43. Callan, E. McC., Imperial College of Tropical Agriculture, St. Augustine, Trinidad, Brit. West Indies. *Hymenoptera.*

Ch. Calvert, Philip P., P. O. Box 14, Cheyney, Pa. (F. '07, H. F. '39). *Odonata.*

'46. Campbell, D. K., Forrest Insect Laboratory, Court House, Vernon, British Columbia, Canada. *Forest Entomology.*

'28. Campbell, Frank Leslie, The Scientific Monthly, Smithsonian Institution Bldg., Washington 25, D. C. (F. '34). *Toxicology.*

'13. CAMPBELL, ROY E., 1208 E. Main, Alhambra, Calif. (F. '41).
'49. Cantrall, Irving J., Edwin S. George Reserve, Pinckney, Mich. *Orthoptera, Dermaptera.*
'14. *Capp, S. B., Box 2054, Philadelphia, Pa.
'40. Capps, Hahn W., Division of Insect Identification, U. S. National Museum, Washington 25, D. C. *Geometridae.*
'33. CARPENTER, F. M., Museum of Comparative Zoology, Harvard University, Cambridge, Mass. (F. '38). *Mecoptera, Neuroptera.*
'26. Carpentier, Fritz, Conservateur á l'Universite, Rue Vivegnis 10 C, Liége, Belgium. *Morphology.*
'31. Carruth, Laurence A., Division of Entomology, University of Arizona, Tucson, Ariz. *Meloidae.*
'22. CARTER, WALTER, P. O. Box 3166, Honolulu, Hawaii. (F. '38). *Insect Transmission of Plant Disease.*
'26. CARTWRIGHT, O. L., Room 383, U. S. National Museum, Washington 25, D. C. (F. '41). *Scarabaeidae.*
'26. Cartwright, William B., Box 495, Lafayette, Ind. *Hessian Fly.*
'45. Castillo, Robert Levi, P. O. Box 3606, Guayaquil, Ecuador, S. Amer. *Culicidae.*
'46. Cazier, Mont A., American Museum of Natural History, Central Park W. at 79th, New York 24, N. Y.
'47. Chadwick, Leigh E., Medical Division, Army Chemical Center, Edgewood Arsenal, Md. *Insect Physiology.*
'22. CHAMBERLAIN, JOSEPH C., P. O. Box 278, Forest Grove, Ore. (F. '38). *Chelonethida, Arachnida.*
Ch. CHAMBERLAIN, R. V., University of Utah, Salt Lake City, Utah.. (F. '17). *Myriapoda, Arachnida.*
'18. Chambers, Ernest L., Room 424 Northeast, State Capitol, Madison, Wis.
'14. Champion, H. G., Department of Forestry, Imperial Forestry Institute, University of Oxford, Oxford, England. *Coleoptera.*
'49. Chao, Hsiu-fu, Fernald Hall, Amherst, Mass.
'18. Chapin, E. A., U. S. National Museum, Division of Insects, Washington 25, D. C.
'15. Chapman, James W., Silliman Institute, Dumaguete, Philippine Islands. *Ants of P. I.*
'41. Chickering, A. M., 206 South Mingo Street, Albion, Mich. *Arachnida.*
'13. Childs, Leroy, Hood River Branch Experiment Station, Hood River, Ore. *Apple and Pear Insects.*
'30. Christenson, L. D., Bureau of Entomology and Plant Quarantine, P. O. Box 1066, Riverside, Calif. *Aptera, Myriapoda.*
'47. Christian, Paul J., 1336½ Vermont Street, Lawrence, Kansas.
'27. Clagg, Charles F., 845 Fourteenth Street, C. H. A. #3, Honolulu, T. Hawaii. *Mecoptera, Hemiptera.*
'14. CLAUSEN, CURTIS P., Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '37). *Insect Parasites.*
'49. Cloyd, Will John, P. O. Box 4258, University Station, Knoxville, Tenn.
'49. Coghill, D., P. O. Box 135, Stellenbosch, South Africa.
'47. Coher, Edward I., 12 Harvard Terrace, Allston 34, Mass.
'28. COLE, ARTHUR C., JR., Department of Zoology, University of Tennessee, Knoxville, Tenn. (F. '43). *Formicidae.*
'16. COLE, F. H., P. O. Box #6, Redlands, Calif. (F. '38). *Diptera, Hymenoptera.*
'47. Collias, Elsie C. (Mrs. Nicholas E.), Biology Bldg., University of Wisconsin, Madison 6, Wis.
'29. Collins, Donald L., 20 Circle Lane, Albany 3, N. Y. *Coleoptera.*
'21. Compton, Charles C, 513 South Pine Street, Champaign, Ill. *Greenhouse and Truck Insects.*
'29. Conklin, J. G., Department of Entomology, University of New Hampshire, Durham, N. H. *Coccinellidae.*
'35. Connell, Walter A., Department of Entomology, University of Delaware, Newark, Del. *Diptera.*
'44. Conroy, John H., 138 Magnolia Street, Westbury, Long Island, N. Y.
'47. Cook, Carl, Crailhope, Ky. *Odonata, Papilionidae.*
Ch. Cook, Melville T., Department of Botany, Bact. & Plant Pathology, Louisiana State University, Baton Rouge, La. (Send Annals to General Library, DePauw University, Greencastle, Ind.). *Entomogenous Fungi.*

'19. COOK, WILLIAM C., 219 Newell Street, Walla Walla, Wash. (F. '38). *Noctuidae.*

'10. COOLEY, R. A., U. S. Public Health Service, Hamilton, Mont. (F. '24). *Ixodidae, Ixodiphiginae.*

'49. Cooper, Calvin L., Box 15, Pateros, Wash.

'36. Cooper, James Furman, Apartado Num. 28562, Tacuba, Mexico 17, D. F., Mexico. *Fruit Insects.*

'47. Cooper, Murray I., Department of Entomology, University of Illinois, Urbana, Ill.

'39. Cope, Oliver B., North Rotunda, Museum Bldg., Stanford University, Calif. *Anoplura, Mallophaga, Diptera.*

'32. Cory, Ernest N., State Entomologist, College Park, Md.

'21. COSTA-LIMA, ANGELO M. DA, Institute Oswaldo Cruz, Caixa Postal 926, Rio de Janeiro, Brazil. (F. '39, H. F. '43). *Economic Entomology.*

'49. Cott, H. Edwin, Division of Entomology, University of California, Berkeley, Calif.

'15. COTTON, RICHARD T., 343 N. Fourteenth Street, Manhattan, Kansas. (F. '37). *Curculionid Larvae.*

'49. Couch, Max D., 303 Harker Hall, Department of Entomology, University of Illinois, Urbana, Ill. *European Corn Borer, Toxicology.*

'35. Couture, Philip G., Room 844, U. S. Department of Agriculture, 641 Washington Street, New York 14, N. Y.

'46. Cowan, Frank A., 1322 Avenue L, Huntsville, Texas. *Biology Muscoids.*

'46. Cox, Sam M., 127 North Tenth Avenue East, Duluth 5, Minn.

'11. *CRAMPTON, G. C., 86 Pleasant Street, Amherst, Mass. (F. '17). *Morphology.*

'39. Crandall, Robert H., Ghost Ranch Lodge, Box 640, Tucson, Ariz. *Hymenoptera.*

'33. Creighton, John T., University of Florida, Gainesville, Fla. *Economic Entomology.*

'49. Crowder, Harold W., 769 Seventh Street, Lawrence, Kansas. *Cicadellidae.*

'38. Crowell, H. H., Department of Entomology, Oregon State College, Corvallis, Oreg. *Physiology.*

'49. Crystal, Maxwell M., 1811 Milvia Street, Berkeley 4, Calif.

'15. CURRAN, C. H., American Museum of Natural History, 77th Street and Central Park W., New York, N. Y. (F. '34). *Diptera.*

'43. Curry, John F., P. O. Box 401, c/o California Department of Agriculture, San Pedro, Calif.

'43. Cutkomp, Laurence K., Division of Entomology, University Farm, St. Paul 1, Minn. *Physiology.*

'21. Cutright, Clifford R., Agricultural Experiment Station, Wooster, Ohio. *Aphidae.*

'35. *Daggy, Richard H., Arabian American Oil Co., Dhahran, Saudi Arabia. *Ephemeroptera.*

'42. Dailey, Ervin F., 825 E. 78th Street, Seattle 5, Wash. *Myriapoda.*

'42. Dalmat, Herbert T., Oficina Sanitaria Panamericana, Apartado #383, Guatemala, Guatemala, C. A.

'44. d'Andretta, Carlos, Jr., Escola Paulista de Medicina, Rua Botucatái 760, (or Caixa Postal 144-A) São Paulo, Brazil. *Taxonomy, Simuliidae.*

'25. DARLINGTON, P. J., JR., Museum of Comparative Zoology, Cambridge, Mass. (F. '38). *Adephaga, Dryopidae.*

'47. da Rocha, Newton Banks, Bom-fim, 335, Olinda, Pernambuco, Brazil.

'49. Darsie, Richard F., Jr., Franklin & Marshall College, Lancaster, Pa. *Mosquitoes.*

'30. DAVIDSON, RALPH H., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio. (F. '43). *Cicadellidae.*

'43. Davidson, Thomas R., Dominion Laboratory of Plant Pathology, University of Alberta, Edmonton, Alberta, Canada. *Aphidae.*

'49. Davis, Dean Frederick, Box 4303 University Station, Knoxville, Tenn.

'22. Davis, Edgar W., Box 218, Union Gap, Wash. *Cicadellidae.*

'49. Davis, Jared James, 417 George Washington Way, Richland, Wash. *Trichoptera, Aquatic Insects.*

Ch. DAVIS, J. J., Purdue University, Lafayette, Ind. (F. '17). *Aphididae, Lachnosterna.*

'33. Dean, Ralph W., Cottage Road, Poughkeepsie, N. Y. *Rhynchophora.*
'36. Dearolf, Kenneth, Chief Curator, Pennsylvania State Museum, Harrisburg, Pa. *Cave Insects.*
'25. DEAY, HOWARD O., Department of Entomology, Purdue University, Lafayette, Ind. (F. '46). *Coreidae, Tenagobia, Micronecta.*
'38. DeBach, Paul H., University of California, Citrus Experiment Station, Riverside, Calif. *Chalcidoidea.*
'24. Decker, George C., Illinois Natural History Survey, Urbana, Ill. *Stalk Borers, Crambus.*
'24. DeCoursey, R. M., University of Connecticut, Storrs, Conn. *Hemiptera.*
'49. DeFoliart, Gene R., 116 Oak Avenue, Ithaca, New York.
'29. DeLeon, Donald, Box 244, Sta. G, Columbus 7, Ohio. *Scolytidae.*
'14. DeLONG, D. M., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio. (F. '30). *Cicadellidae.*
'34. *DENNING, DONALD G., Department of Entomology, University of Wyoming, Laramie, Wyo. (F. '43). *Trichoptera, Corethrinae.*
'34. *Deonier, C. C., R. R. #1, Harrah, Okla. *Muscidae.*
'46. Dethier, V. G., Department of Biology, The Johns Hopkins University, Baltimore 18, Md. *Insect Physiology.*
'44. Detjen, Gustav H. H., 303 West 42nd Street, New York 18, N. Y.
'27. Dicke, Ferdinand F., Box 97, Highland Park Station, Des Moines 13, Iowa. *Harmolita Parasites.*
'39. Dickson, Robert C., Department of Entomology, Citrus Experiment Station, Riverside, Calif. *Aphididae, Coccidae.*
'22. DIETRICH, HENRY, Comstock Hall, Cornell University, Ithaca, N. Y. (F. '43). *Coleoptera.*
'35. Dillon, Lawrence S., Department of Biology, A. & M. College of Texas, College Station, Texas. *Cerambycidae.*
'24. Dills, L. E., Department of Zoology and Entomology, Pennsylvania State College, State College, Pa.
'26. Dirks, C. O., 32 Coburn Hall, University of Maine, Orono, Maine. *Biology of Lepidoptera.*
'31. *Ditman, L. P., University of Maryland, College Park, Md. *Ecology.*
'27. *Doak, K. D., Route A., Crown Point, Ind. *Gelechiidae.*
'36. *Dodge, Harold R., U. S. P. H. S., Communicable Diseases Center, 291 Peachtree Street, Atlanta, Ga. *Scolytidae.*
'22. DOERING, KATHLEEN C., Department of Entomology, University of Kansas, Lawrence, Kansas. (F. '35). *Cercopidae, Fulgoridae.*
'49. Dogger, James R., Department of Entomology, Oklahoma A. and M. College, Stillwater, Okla.
'41. Dorsey, Carl K., 437 Woodlawn Avenue, Webster Groves, Mo. *Immature Coleoptera.*
'37. Dorst, Lt. Col. Howard E., Box 109, U. S. A. C., Campus, Logan, Utah. *Cicadellidae.*
'22. Doucette, Charles F., Box 458, Sumner, Wash. *Ornamental Insects.*
'23. Douglass, J. R., Box 1100, Twin Falls, Idaho.
'45. Doutt, Richard L., 1050 San Pablo Avenue, Albany 6, Calif. *Mymaridae.*
'28. DOVE, W. E., Defense Hiway, Gambrills, Md. (F. '40). *Parasites.*
'31. Dow, Richard, Dysentery Studies Project, Public Health Service FSA, Box 270, Thomasville, Ga. *Sphecoid Wasps.*
'22. DOWDEN, PHILIP B., 335 Prospect Street, New Haven 11, Conn. (F. '46). *Parasitic Hymenoptera.*
'49. Downes, William L., Jr., 3974 Juniata, St. Louis 16, Mo.
'22. DRAKE, CARL J., Iowa State College, Ames, Iowa. (F. '31). *Tingitidae.*
'37. Dreisbach, Robert H., 301 Helen Street, Midland, Mich. *Hymenoptera.*
'49. Dresner, Edgar, 235 Stone Avenue, Yonkers, N. Y.
'38. Drolet, Marcel, 95 Stefoy Road, Quebec, Quebec, Canada. *Cerambycidae.*
'45. duChanois, Francis Robert, 856 Pammel Court, Ames, Iowa. *Formicidae, Muscoidea.*
'26. Dunavan, David, 116 North Clemson Avenue, Clemson, S. C. *Haliplidae.*
'23. DUNCAN, CARL D., Box 4, Stanford University, Calif. (F. '41). *Vespidae, Bembicidae.*
'28. Dunnam, E. W., Box 8, Leland, Miss. *Cotton Resistance to Insects.*
'14. Dusham, E. H., 212 Frear Laboratories, State College, Pa. *Coleoptera.*

'43. Dybas, Henry S., Division of Insects, Chicago Natural History Museum, Chicago 5, Ill. *Ptiliidae, Nanosellinae.*

'49. Eads, Richard B., Division of Entomology, Texas State Department of Health, Austin, Texas. *Siphonaptera.*
Ch.   Easton, Norman S., 458 High Street, Fall River, Mass. *Coleoptera.*
'44. Eaton, Charles B., Forest Insect Laboratory, 623 North Second Street, Milwaukee 3, Wisconsin. *Forest Insects.*
'46. Eberlein, George, West Concord, Mass.
'31. ECKERT, J. E., University Farm, University of California, Davis, Calif. (F. '43). *Beekeeping.*
'36. Eddy, C. Brayton, New York Zoological Society, N. Y. Zoological Park, New York 60, N. Y.
'23. EDDY, C. O., Niagara Sprayer and Chemical Co., Middleport, N. Y. (F. '31).
'49. Edmunds, George F., Jr., Division of Biology, University of Utah, Salt Lake City, Utah.
'49. Edwards, George A., Department of Biology, Tufts College, Medford 55, Mass. *Insect Physiology.*
'49. Elbel, Robert Edwin, 821 Mississippi Street, Lawrence, Kansas.
'40. Elishewitz, Harold, Dept. Microbiology & Public Health, Chicago Medical School, 710 South Wolcott Avenue, Chicago 12, Ill. *Ixodoidea.*
'49. Ellis, Leslie L., Jr., Department of Zoological Sciences, University of Oklahoma, Norman, Okla.
'24. Elmore, J. C., 1208 East Main, Alhambra, Calif. *Truck Crop Insects.*
'19. EMERSON, ALFRED E., Department of Zoology, University of Chicago, Chicago, Ill. (F. '37). *Isoptera, Termitophiles.*
'38. Emerson, K. C., 31-C Victory Apts., Columbus, Ga. *Mallophaga, Anoplura.*
'25. Enders, Howard E., 249 Littleton Street, West LaFayette, Ind. *Mallophaga.*
'43. Esselbaugh, Charles O., 303 S. Tracy Avenue, Bozeman, Mont. *Pentatomidae, Scutelleridae.*
'10. ESSIG, E. O., University of California, Berkeley, Calif. (F. '26). *Aphididae, Coccidae.*
'49. Evans, Howard E., Department of Entomology, Kansas State College, Manhattan, Kansas.
'30. Everly, Ray T., Department of Entomology, Agric. Exp. Annex, Purdue University, West Lafayette, Ind. *Carabidae.*
'10. EWING, HENRY E., U. S. National Museum, Washington 25, D. C. (F. '28). *Acarina.*
'18. EYER, JOHN R., State College, N. Mexico. (F. '38). *Cicadellidae, Chermidae.*

'32. FAIRCHILD, GRAHAM BELL, Box 651, Ancon, Canal Zone. (F. '43). *Culicidae, Tabanidae, Phlebotomus, Ticks.*
'40. Fallis, A. Murray, Ontario Research Foundation, 43 Queens Park, Toronto 5, Ontario, Canada. *Insect Parasites.*
'35. Falls, Olive, 6345 University Avenue, Chicago, Ill. *Termite Biology.*
'30. Farquhar, Donald W., 185 Claremont Avenue, New York 27, N. Y. *Lepidoptera of New England.*
'49. Farr, Thomas H., 353 Hall Street, S. E., Grand Rapids, Mich.
'17. Fattig, P. W., Box 788, Emory University, Ga.
'45. Faure, Gabriel O., Dept. Sanidad Vegetal, Casilla 4647, Santiago, Chile, S. Am.
'34. Fay, Richard William, 417 East 53rd Street, Savannah, Ga. *Insect Physiology.*
Ch.   FERNALD, H. T., 1128 Oxford Road, Winter Park, Fla. (F. '14, H. F. '37). *Sphecidae.*
'47. Fernández-Yépez, Francisco, Division de Entomologia, Apartado 643, Edo. Aragua, Maracay, Venezuela.
'14. FERRIS, G. F., Natural History Museum, Stanford University, Calif. (F. '34). *Coccidae, Mallophaga, Anoplura, Diptera.*
'49. Field, Gordon, Fernald Hall, University of Massachusetts, Amherst, Mass.
'35. FIELD, WILLIAM D., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '46). *Arctiidae, Lycaenidae.*
Ch.   Field, William L. W., 75 Vose's Lane, Milton 87, Mass.

'31. Filmer, Robert Sterling, Rutgers Univ., New Brunswick, N. J. *Hymenoptera*.
'49. Fischer, Roland L., Department of Entomology, Kansas State College, Manhattan, Kansas.
'49. Fisher, Dorothy A., 125 Ensley Street, Huntington 3, W. Va.
'35. Fisher, Elizabeth G., 20 Blythewood Road, Baltimore 10, Md. *Odonata, Mycetophilidae*.
'36. Fisk, Frank W., Department of Zoology and Entomology, Ohio State University, Columbus, Ohio. *Culicidae*.
'30. FLANDERS, STANLEY E., Citrus Experiment Station, Riverside, Calif. (F. '37). *Biology of Chalcidoidea*.
'49. Fleschner, C. A., Citrus Exp. Sta., University of California, Riverside, Calif.
'22. Fletcher, Frank C., Room 301, 100 Gibbs Street, Rochester 1, N. Y. *Coleoptera*.
'31. Fletcher, Fred W., Department of Biochemistry, Dow Chemical Company, Midland, Mich. *Insecticides*.
'43. Flock, Robert A., Citrus Experiment Station, Riverside, Calif.
'24. FLUKE, C. L., King Hall, University of Wisconsin, Madison 6, Wisc. (F. '35). *Syrphidae*.
'45. Fontaine, Russell E., Box 884, Curundu, Canal Zone.
'38. Forbes, James, 2986 Marion Avenue, New York 58, N. Y. *Formicidae*.
'08. *FORBES, WILLIAM T. M., Cornell University, Ithaca, N. Y. (F. '30). *Lepidoptera, Neuropteroids*.
'30. Foster, Charles E., Colgate University, Hamilton, N. Y. *Coccidae*.
'46. Fox, Irving, School of Tropical Medicine, San Juan, Puerto Rico. *Ectoparasites, Culicoides*.
'11. FRACKER, S. B., Bureau of Entomology and Plant Quarantine, U. S. Dept. of Agri., Washington, D. C. (F. '34). *Coreidae*.
'47. Franclemont, John G., Division of Insects, U. S. National Museum, Washington 25, D. C.
'23. FREEBORN, STANLEY B., 101 Giannini Hall, University of California, Berkeley, Calif. (F. '38). *Culicidae*.
'49. French, Ellery W., Dept. of Entomology, University of Hawaii, Honolulu 10, Hawaii. *Lepidoptera*.
'49. Frick, Kenneth E., Irrigation Exp. Sta., Prosser, Wash. *Agromyzidae*.
'22. FRIEND, ROGER B., Agricultural Experiment Station, 153 Huntington Street, New Haven, Conn. (F. '38). *Diptera*.
'44. Frizzell, Harriet Exline, 6 Rolla Gardens, Rolla, Mo. *Araneida*.
'40. Froeschner, Richard C., 712 Crawford Street, Ames, Iowa. *Hemiptera*.
'40. Fronk, W. Don, Department of Zoology and Entomology, Iowa State College, Ames, Iowa.
Ch. FROST, C. A., 67 Henry Street, Framingham, Mass. (F. '44). *Coleoptera*.
'14. FROST, STUART W., 465 East Foster Avenue, State College, Pa. (F. '35). *Agromyzidae, Hispinae*.
Ch. FULLAWAY, D. T., Agricultural Board, Box 3319, Honolulu, Hawaii. (F. '40). *Parasitic Hymenoptera, Braconidae*.
'16. FULTON, B. B., State College, Raleigh, N. C. (F. '32). *Orthoptera*.
'40. Furniss, Robert L., 445 U. S. Court House, Portland, Oreg. *Forest Entomology*.

Ch. GAHAN, A. B., U. S. National Museum, Washington 25, D. C. (F. '28). *Chalcidoidea*.
'49. Gaines, J. C., Department of Entomology, Texas A. & M. College, College Station, Texas.
'26. Galindo, Pedro, Apartado 1443, Panama, Republica de Panama.
'47. Gammons, John G., 2911 Dinwiddie Street, Apt. C-1, Fairlington, Arlington, Va. *Culicidae, Anoplura*.
'49. Gardner, Theodore R., 25 Meadowbrook Road, Chatham, N. J.
'22. Garlick, W. G. P., Vineland Station, Ontario, Canada. *Tenthredinoidea*.
'14. GARMAN, PHILIP, Agri. Exp. Sta., New Haven, Conn. (F. '38). *Odonata, Acarina*.
'49. Garner, William Vaughn, 447 E. Wadsworth Street, Philadelphia 19, Pa.
'49. Garrett, L. C., 707 S. Third Street, Champaign, Ill.
'46. Gaul, Albro, 401 Washington Avenue, Brooklyn 5, N. Y. *Vespinae, Polistinae*.

'39. Gauthier, Georges, Entomologiste, Ministére de l'Agriculture, Quebec, Canada.

'16. GENTNER, LOUIS G., 22 Groveland Avenue, Medford, Oreg. (F. '44). *Halticinae.*

'45. Gerberich, John B., Department of Zoology, University of Minnesota, Duluth Branch, Duluth 5, Minn. *Medical Entomology and Immature Insects.*

Ch. GERHARD, WILLIAM J., Chicago Museum of Natural History, Chicago 5, Ill. (F. '43). *Hemiptera.*

'44. Gerlach, Charles F., Michigan Chemical Corporation, St. Louis, Mich.

'22. Gerry, Bertram I., Box 28, Wellesley Hills 82, Mass. *Culicidae and Chironomidae.*

'32. GERTSCH, WILLIS J., American Museum of Natural History, 79th St. and Central Park West, New York, N. Y. (F. '40). *Arachnida.*

'49. Ghani, M. A., Ag. College & Research Institute, Lyallpur (West Punjab), Pakistan (Western).

Ch. GIBSON, ARTHUR, Maitland, Ontario, Canada. (F. '17).

'14. Gibson, E. H., Trinity Episcopal Church, Galveston, Texas. *Hemiptera.*

'49. Gillenwater, Hagen B., 1933 McCalla Avenue, Knoxville, Tenn.

'21. Gilmer, Paul M., Coastal Plains Experiment Station, Tifton, Ga. *Cotton Insects.*

'39. Glick, Perry A., Box 143, College Station, Texas. *Cotton Insects, Lepidoptera.*

'30. Glover, Louise Haas, Shell Agricultural Laboratory, Modesto, Calif. *Carabidae.*

'49. Gloyd, Leonora K., Illinois Natural History Survey, Urbana, Ill. *Odonata.*

'46. Goldberg, Alma Rutledge, 621 St. Johns Road, Baltimore 10, Md.

'30. GOOD, NEWELL E., U. S. Public Health Service, 605 Volunteer Building, Atlanta 3, Ga. (F. '43). *Siphonaptera, Culicidae, Stored Grain Beetles.*

'44. Goodwin, Melvin H., Jr., Assist. Sanitarian, U. S. P. H. S., Newton, Ga. *Diptera-Culicidae.*

'36. Gouck, Harry K., P. O. Box 32, Urbana, Ill. *Plecoptera.*

'31. Gould, George E., Purdue University, Lafayette, Ind. *Rhagovelia, Semi-aquatic Hemiptera.*

'39. Graham, Lewis T., Southwestern Station, Box 403, Lafayette, La. *Membracidae.*

'17. GRAHAM, SAMUEL A., University of Michigan, Ann Arbor, Mich. (F. '32). *Forest Insects.*

'22. GRANOVSKY, A. A., Division of Entomology, University Farm, St. Paul 1, Minn. (F. '35). *Aphiidae, Phyllophaga.*

'25. Grant, U. S., IV, Natural History Museum, Balboa Park, San Diego, Calif.

'49. Grayson, James McDonald, Agri. Exp. Sta., Blacksburg, Va.

'17. Green, J. W., R. D. #2, Easton, Pa. *Cantharidae, Lampyridae.*

'49. Greenburg, Bernard, 1234 Mississippi Street, Lawrence, Kansas.

'43. Gregg, Robert E., Department of Biology, University of Colorado, Boulder, Colo. *Ants.*

'36. *GRESSITT, J. LINSLEY, Natural History Survey & Museum, Lingnan University, Canton, China. (F. '43). *Coleoptera.*

'34. GRIFFITH, MELVIN E., Department of Zoological Sciences, University of Oklahoma, Norman, Okla. (F. '47). *Alconeura, Collembola, Culicidae.*

'42. Griffiths, James T., Jr., Citrus Experiment Station, Lake Alfred, Fla.

'49. Grosch, Daniel S., Zoology Department, North Carolina State College, Raleigh, N. C. *Hymenoptera.*

'33. *GURNEY, ASHLEY B., Division of Insects, U. S. National Museum, Washington, D. C. (F. '43). *Orthoptera, Zoroptera, Corrodentia.*

'49. Gyrisco, George C., Comstock Hall, Cornell University, Ithaca, N. Y.

'24. HAEUSSLER, GILBERT J., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '41). *Ichneumonidae, Braconidae.*

'49. Haga, Mary Juola, 3201 Kyle Avenue, Minneapolis, Minn.

'14. HAGAN, HAROLD R., Department of Biology, College of the City of New York, 139th and Convent Avenue, New York 31, N. Y. (F. '38). *Embryology.*

'47. Hagen, Kenneth S., Division of Biological Control, University of California, Gill Tract, 1050 San Pablo Avenue, Albany 6, Calif. *Notoxus, Amblyderus and Mecynotarsus.*

'25. HALL, DAVID G., 593 Arlington Village, Arlington, Va. (F. '41). *Sarcophaga, Diptera.*
'49. Ham, George Forrest, P. O. Box 8328, U. of Tennessee, Knoxville, Tenn.
'41. Hambleton, Edson J., Office of Foreign Agricultural Relations, U. S. Dept. of Agriculture, Washington 25, D. C. *Tingitidae* (Neotropical).
'47. Hamed Ali, Mir, Division of Entomology, University Farm, St. Paul, Minn.
'22. Hamner, A. L., Box 223, State College, Miss. *Aphididae, Phylloxera.*
'46. *Hanan, Blake B., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio.
'44. Hansens, Elton J., New Jersey Agri. Exp. Sta., New Brunswick, N. J.
'39. Hanson, John F., 47 Mt. Pleasant Street, Amherst, Mass. *Plecoptera.*
'39. Harden, Philip H., Pasadena College, Howard at Bresee Avenue, Pasadena 7, Calif. *Plecoptera.*
'37. Hardy, D. Elmo, Department of Zoology and Entomology, University of Hawaii, Honolulu, Hawaii.
'07. *HARNED, R. W., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '27).
'33. Harper, Lawrence C., R. R. #1, Lafayette, N. Y. *Diptera.*
'29. HARRIES, F. H., 151 West Eleventh Avenue, Columbus, Ohio. (F. '43). *Ecology, Physiology.*
'23. HARRIS, HALBERT M., Department of Zoology, Iowa State College, Ames, Iowa. (F. '37). *Hemiptera.*
'47. Harpster, Hilda T., Woman's College of University of North Carolina, Greenboro, N. C.
'42. Hart, Thomas A., American Consultate, Cochabamba, Bolivia, S. Amer.
'39. Hartnack, Hugo, 324 North Fourth Street, Tacoma, Wash.
'21. Hartzell, Albert, Boyce Thompson Institute, 1086 N. Broadway, Yonkers 3, N. Y. *Cicadellidae.*
'07. Hartzell, F. Z., Agricultural Experiment Station, Geneva, N. Y. *Coleoptera.*
'46. Hasbrouck, Frank, 303 Harker Hall, University of Illinois, Urbana, Ill.
Ch. Haseman, Leonard, Whitten Hall, Department of Entomology, University of Missouri, Columbia, Mo. *Psychodidae.*
'32. HASKINS, CARYL P., Green Acre Lane, Westport, Conn. (F. '44). *Formicidae, Hymenoptera.*
'20. HATCH, MELVILLE H., Department of Zoology, University of Washington, Seattle 5, Wash. (F. '38). *Coleoptera.*
'38. Hathaway, Edward S., Department of Zoology, Tulane University, New Orleans, La. *Ecology of Marsh Insects.*
'32. Haub, James G., Department of Zoology, Ohio State University, Columbus 10, Ohio. *Physiology.*
'39. Haude, William J., c/o John Powell & Co., One Park Avenue, New York, N. Y. *Culicidae.*
'30. Haug, Gordon W., Kelowna, British Columbia, Canada. *Formicidae.*
'35. HAYDAK, N. H., Division of Entomology, University Farm, St. Paul 8, Minn. (F. '47). *Honeybee Nutrition.*
'19. HAYES, WILLIAM P., Entomology Building, University of Illinois, Urbana, Ill. (F. '29). *Larvae.*
'31. Heaton, Robert R., 518 Architects & Builders Bldg., Indianapolis 4, Ind. *Fulgoridae, Homoptera.*
'32. Henderson, Charles F., Box 2280, Honolulu, T. Hawaii. *Parasites of Scale Insects.*
'31. HENDERSON, LYMAN S., Bureau of Entomology and Plant Quarantine, U. S. Dept. of Agri., Washington 25, D. C. (F. '43). *Curculionidae.*
'49. Henry, Laura M., Department of Zoology, Florida State University, Tallahassee, Fla.
Ch. HERRICK, GLENN W., 219 Kelvin Place, Ithaca, N. Y. (F. '14). *Thysanoptera, Coccidae.*
'46. Hershberger, Ruth V., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio.
'43. Hertig, Major Marshall, Sn. C., Gorgas Memorial Lab., Apartado 1252, Panama, Rep. de Panama.
'28. Hickman, J. R., Normal College, Ypsilanti, Mich. *Haliplidae.*
'46. Hilchey, John Duncan, Comstock Hall, Cornell University, Ithaca, N. Y.
'08. HILTON, WILLIAM A., 1263 Dartmouth Avenue, Claremont, Calif. (F. '39). *Symphyla, Pauropoda.*

'27. HINMAN, E. HAROLD, Dept. of Public Health, University of Oklahoma, Norman, Okla. (F. '37). *Culicidae.*
'27. Hockenyos, George L., 213 E. Jefferson Street, Springfield, Ill. *Economic Entomology.*
'38. Hodge, Charles, 4th, Dept. of Biology, Temple University, Philadelphia, Pa. *Coleoptera.*
Ch.   Hodgkiss, H. E., 147 W. Park Avenue, State College, Pa. *Eriophyiidae.*
'29. HODSON, A. C., Division of Entomology, University Farm, St. Paul, Minn. (F. '43). *Ecology.*
'44. Hoff, C. Clayton, Department of Biology, University of New Mexico, Albuquerque, N. M. *Pseudoscorpions.*
'49. Holland, George P., Department of Agriculture, Division of Entomology, Ottawa, Ontario, Canada.
'29. Hoffmann, Clarence H., Box 71, Bowie, Md. *Scarabaeidae, Trichiotinax, Osmoderma.*
'49. Hofmaster, Richard N., Virginia Truck Experiment Station, Box 2160, Norfolk, Va. *Sugar beet leafhoppers.*
'20. HOFFMANN, WILLIAM E., Lingnan University, Canton, China. (F. '39). *Hemiptera.*
'35. Holway, Richard T., NAMRU #3, c/o CNO (op 32), Dispatch Sec., Navy Dept., Washington 25, D. C. *Termites.*
'38. Hoogstraal, Harry, Chicago Natural History Museum, Chicago 5, Ill. *Morphology, Culicidae.*
'34. HORSFALL, WILLIAM R., Department of Entomology, University of Illinois, Urbana, Ill. (F. '43). *Bionomics: Culicidae.*
'49. Hopla, Cluff E., Department of Entomology, University of Kansas, Lawrence, Kansas. *Medical Entomology.*
'34. HOSKINS, W. M., 112 Agriculture Hall, University of California, Berkeley, Calif. (F. '47). *Physiology.*
'24. Hough, W. S., Winchester, Va. *Apple Insects.*
'49. House, Howard L., Dominion Parasite Laboratory, Belleville, Ontario, Canada.
'44. Hovanitz, William, Department of Biology, University of San Francisco, San Francisco 17, Calif. *Lepidoptera, Genetics, Physiology.*
'39. Hovey, Charles L., Box 728, Eastern States Farmers Exchange, Hedrick Building, West Springfield, Me. *Aphiidae.*
Ch.   HOWARD, L. O., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '07, H. F. '24). *Chalcidoidea.*
'14. HOWARD, NEALE F., 151 W. 11th Avenue, Columbus, Ohio. (F. '44). *Mexican Bean Beetle, Truck Crop Insects.*
'49. Howell, D. E., Department of Entomology, Oklahoma A. & M. College, Stillwater, Okla.
'39. Howland, A. F., 1208 E. Main Street, Alhambra, Calif. *Tomato Insects.*
'49. Hoyt, Charles Peterson, N. H. Museum, Stanford University, Palo Alto, Calif.
'23. HUBBELL, THEODORE H., Museum of Zoology, University of Michigan, Ann Arbor, Mich. (F. '39). *Orthoptera.*
'20. HUCKETT, H. C., Long Island Vegetable Research Farm, Riverhead, Long Island, N. Y. (F. '38). *Muscidae.*
'39. Hughes, John H., Division of Biological Science, University of Georgia, Athens, Ga. *Chrysomelidae.*
'16. HUNGERFORD, H. B., 323 Snow Hall, University of Kansas, Lawrence, Kansas. (F. '27). *Aquatic Hemiptera.*
'49. Hunt, Burton P., Department of Zoology, University of Miami, Miami, Fla. *Chalcididae.*
'43. Hunt, Charles R., Horticulture Branch Exp. Sta., Corvallis, Mont. *Collembola.*
'47. Hurd, Paul D., Jr., 112 Agriculture Hall, University of California, Berkeley 4, Calif.
'36. Hurlbut, Herbert S., Naval Medical Research Institute, National Naval Medical Center, Bethesda 14, Md. *Culicidae.*
'49. Hussey, Roland F., Department of Biology, Florida Southern College, Lakeland, Fla.
'38. Hutson, Ray, Department of Entomology, Michigan State College, East Lansing, Mich. *Insecticides.*

'49. Hyland, Kerwin E., Jr., Department of Zoology, Duke University, Durham, N. C. *Acarina, Trichoptera.*
'08. Hyslop, James A., Arsenal, Silver Spring, Md. (F. '35). *Elateridae.*

'31. Ide, F. P., Department of Zoology, University of Toronto, Toronto 5, Ontario, Canada. (F. '40). *Ephemeroptera.*
'49. Iglinsky, William, Jr., Box 1836, College Station, Texas.
'19. *Illingworth, J. F., Bishop Museum, Honolulu, Hawaii. (F. '40). *Muscoidea.*
'49. Inada, Constance Sadako, Department of Entomology, University of Hawaii, Honolulu 10, Hawaii.
'28. Ingram, J. W., Box 387, Houma, La. *Sugarcane Insects.*
'14. Isely, Dwight, Box 3, University Station, Fayetteville, Ark. (F. '34). *Chrysomelidae, Curculionidae.*
'27. Ives, J. D., Jefferson City, Tenn. *Cave Insects.*
'34. Ivy, Edward E., Dept. of Entomology, Texas A. & M., College Station, Texas.

'41. James, Brother Cyprian, Manhattan College, Spuytan Duyvil Parkway, New York 63, N. Y. *Psyllidae.*
'38. James, Dr. Freburn L., 1815½ E. Chevy Chase Drive, Glendale 6, Calif. *Coleoptera.*
'31. James, Maurice T., Department of Zoology, State College of Washington, Pullman, Wash. (F. '40). *Diptera, especially Stratiomyidae.*
'49. Jameson, Everett Williams, Jr., Department of Zoology, University of California, Davis, Calif.
'30. Janes, Melvin J., 89 Haven Avenue, Port Washington, N. Y. *Economic Entomology.*
'35. Jaques, Harry E., 709 N. Main Street, Mount Pleasant, Iowa. *Insect Ecology.*
'30. Jaynes, Harold A., Brooksvale Avenue, Mt. Carmel, Conn. *Tiphia of S. A.*
'47. Jenkins, Dale, Medical Division, Army Chemical Center, Edgewood, Md.
'41. Jensen, Dilworth D., 112 Agriculture Hall, University of California, Berkeley, Calif. *Psyllidae.*
'15. Jewett, H. H., Agricultural Experiment Station, Lexington, Ky. *Tobacco and Forage Crop Insects.*
Ch.   Johannsen, O. A., 203 Parkway, Ithaca, N. Y. (F. '14, H. F. '39). *Diptera.*
'46. Johnson, Donald Ross, Division of Entomology, University Farm, St. Paul 1, Minn.
Ch.   Jones, Frank M., 2000 Riverview Avenue, Wilmington 47, Del. (F. '46). *Psychidae.*
'47. Jones, Jack Colvard, Lab. Tropical Diseases, National Institutes of Health, Bethesda, Md. *Coleoptera.*
'39. Jones, J. R. J. Llewellyn, "Arranmore," R. M. D. #1, Cobble Hill, British Columbia, Canada. *Ecology of Lepidoptera Larvae.*
'41. Jones, Joseph W., 1608 Wickam Avenue, Newport News, Va. *Culicidae, Ants (Ponera).*
'45. Joyce, Charles R., Department of Zoology and Entomology, Iowa State College, Ames, Iowa. *Culicidae, Ixodoidea, Siphonaptera.*
'46. Judd, William W., Department of Zoology, McMaster University, Hamilton, Ontario, Canada.

'42. Kadner, Carl G., Loyola University, Los Angeles, Calif. *Hippoboscidae, Culicidae.*
'34. Kagy, J. Franklin, c/o Dow Chemical Company, P. O. Box 245, Seal Beach, Calif. *Insect Toxicology.*
'34. Kearns, Clyde W., Department of Entomology, University of Illinois, Urbana, Ill. (F. '47). *Insecticides.*
'29. Keck, Chester B., 2142 Lanihuli Drive, Honolulu, Hawaii. *Ecology.*
'49. Keister, Margaret L., National Institutes of Health, Bethesda, Md. *Sciara.*
'14. *Kennedy, C. H., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio. (F. '27). *Odonata, Ants.*
'49. Khan, Nawab Hasan, Fernald Hall, University of Massachusetts, Amherst, Mass. *Tabanidae.*

'47. King, Edwin W., 401 So. Coler Avenue, Urbana, Ill. *Phylogeny of Coleoptera.*
'12. KING, J. L., Box 150, Moorestown, N. J. (F. '32). *Biological Control.*
'28. KING, WILLARD V., Box 3391, Orlando, Fla. (F. '38). *Culicidae.*
'18. KINSEY, ALFRED C., Indiana University, Bloomington, Ind. (F. '28).
      Cynipidae.
'38. KLOTS, ALEXANDER B., Department of Biology, The City College of New
      York, 17 Lexington Avenue, New York, N. Y. (F. '47). *Lepidoptera,*
      Pyralididae, Culicidae.
'45. Knapp, Virgil R., R. R. #1, Box 100, Zionville, Ind. *Aphididae.*
'11. KNIGHT, H. H., Department of Zoology, Iowa College, Ames, Iowa. (F. '28).
      Hemiptera, Miridae.
'40. Knight, Kenneth L., Naval Medical Research Institute, Naval Medical
      Center, Bethesda 14, Md. *Geometrid Larvae, Mosquitoes.*
'24. KNOWLTON, GEORGE F., Utah State Agriculture College, Logan, Utah.
      (F. '43). *Aphididae.*
'34. KNULL, MRS. DOROTHY, 330 East Dunedin Road, Columbus 2, Ohio. (F. '43).
      Cicadellidae, Cercopidae.
'34. KNULL, JOSEF N., Department of Zoology and Entomology, Ohio State
      University, Columbus 10, Ohio. (F. '43). *Cleridae, Elateridae, Buprestidae,*
      Cerambycidae.
'37. Knutson, Herbert C., Rhode Island State College, Kingston, R. I.
      Phalaenidae, Culicidae.
'17. Kraatz, Walter C., Department of Biology, University of Akron, Akron,
      Ohio.
'41. Kramer, Sol, Department of Zoology, University of Wisconsin, Madison, Wis.
'45. Krauss, Noel Louis H., Plant Quarantine Inspector, Territory of Hawaii,
      2437 Parker Place, Honolulu 5, Hawaii.
'40. Kretzschmar, Gerhard, 3221 Plumb Street, Houston 5, Texas. *Soybean*
      Insects.
'49. Kring, James Burton, Department of Entomology, Kansas State College,
      Manhattan, Kansas.
'34. KROMBEIN, KARL VON VORSE, Division of Insects, U. S. National Museum,
      Washington 25, D. C. (F. '44). *Aculeate Hymenoptera.*
'41. Kuitert, Louis C., Agricultural Experiment Station, University of Florida,
      Gainesville, Fla. *Nepidae, Gerridae.*
'36. Kulash, Walter M., Department of Zoology and Entomology, North Carolina
      State College, Raleigh, N. C. *Collembola.*

'49. Labrecque, Germain C., Box 8274, University of Tennessee, Knoxville, Tenn.
'45. Laffoon, Jean L., 2824 Ross Road, Ames, Iowa. *Diptera.*
'46. LaHue, Dalmon W., Georgia Coastal Plain Experiment Station, Tifton, Ga.
'46. Laidlaw, Harry H., Division of Entomology and Parasitology, Agr. Exp.
      Sta., University of California, Davis, Calif.
'49. Lambert, Robert, Bureau of Entomology, 53 Grande-Allee, Quebec, Canada.
'28. Lamiman, J. F., California Polytechnic College, San Dimas, Calif. *Acarina.*
'30. LANDIS, B. J., P. O. Box 202, Union Gap, Wash. (F. '40). *Biological Control.*
'42. Lane, John, Instituto de Higiene de São Paulo, Caixa Postal 99 B, São
      Paulo, Brazil.
'40. Lange, W. Harry, Jr., Division of Entomology, University of California,
      Davis, Calif. *Lepidoptera.*
'25. Langford, George S., Department of Entomology, University of Maryland,
      College Park, Md. *Economic Entomology.*
'46. Lanham, Urless N., Department of Zoology, University of Michigan, Ann
      Arbor, Mich.
'17. Langston, James M., State College, Miss. *Phyllophaga.*
'37. LaRivers, Ira, Department of Biology, University of Nevada, Reno, Nev.
      Odonata, Psychoididae.
'38. Larson, N. P., Box 674, Hulmeville, Pa. *Physiology.*
'37. Lassmann, G. W., Independencia #2, Jalapa, Vera Cruz, Mexico. *Culicidae.*
'49. Latham, Roy, Orient, Long Island, N. Y.
'13. LATHROP, F. H., Agricultural Experiment Station, Orono, Maine. (F. '41).
      Cicadellidae.
'40. Latta, Randall, Agricultural Research Center, Beltsville, Md. *Toxicology.*
'49. Lattin, John D., 5726 W. Ohio Street, Chicago 44, Ill.

'23. Lauderdale, J. L. E., P. O. Box 2006, Phoenix, Ariz.
'47. Lawson, Fred A., Department of Zoology and Entomology, University of Tennessee, Knoxville, Tenn.
'17. LAWSON, PAUL B., 2215 Vermont Street, Lawrence, Kansas. (F. '31). *Cicadellidae.*
'39. Leech, H. B., Department of Entomology, California Academy of Science, Golden Gate Park, San Francisco 18, Calif. *Coleoptera.*
'12. LEIBY, R. W., Comstock Hall, Cornell University, Ithaca, N. Y. (F. '40). *Embryology.*
'38. Leonard, Justin W., Institute for Fisheries Research, University Museums Annex, Ann Arbor, Mich. *Aquatic Insects.*
'11. LEONARD, MORTIMER D., 2480 Sixteenth Street N. W., Washington, D. C. (F. '46). *Aphididae.*
'47. Lienk, Sigfried E., New York State Agricultural Exp. Sta., Department of Entomology, Geneva, N. Y.
'33. Lilly, John H., Department of Zoology and Entomology, Iowa State College, Ames, Iowa. *Coleophoridae.*
'34. Lindgren, David L., University of California, Citrus Experiment Station, Riverside, Calif. *Toxicology.*
'39. Lindquist, Arthur W., Box 332, Corvallis, Ore. *Chironomidae.*
'46. Lindsay, Capt. Dale R., 218 W. Kelly, Pharr, Texas. *Diptera.*
'17. LINDSEY, A. W., Denison University, Granville, Ohio. (F. '40). *Hesperioidea.*
'33. *LINSLEY, E. GORTON. 112 Agricultural Hall, University of California, Berkeley, Calif. (F. '41). *Cerambycidae, Coleoptera.*
'47. Lipovsky, Louis J., Department of Entomology, University of Kansas, Lawrence, Kansas. *Acarina.*
'25. LIST, GEORGE M., Agricultural College, Fort Collins, Colo. (F. '32). *Cimicidae.*
'30. Livingstone, E. M., 4425 Bienville Avenue, New Orleans, La.
'31. Lloyd, Llewellyn, University of Leeds, London, England.
'19. Lobdell, Mrs. Gladys H., Route 2, Brevard, N. C. *Coccidae.*
'46. Ludwig, Carl E., Biology Department, Sacramento State College, Sacramento 14, Calif.
'38. Ludwig, Daniel, Department of Biology, New York University, 181st Street and University Avenue, New York 53, N. Y. *Physiology.*
'13. LUGINBILL, PHILIP, Box 495, Lafayette, Ind. (F. '41). *Phyllophaga.*
'34. Lund, Horace O., Division of Biological Sciences, University of Georgia, Athens, Ga. *Culicidae.*
'31. Lyle, Clay, Box 1538, State College, Miss. *Crustacea.*
'40. Lyman, F. Earle, U. S. P. H. S., P. H. S. 3472, 412 Hilldale Avenue, Decatur, Ga. *Aquatic Insects, Ephemeroptera.*

'43. Mackenzie, George P., 1284 Sherwood Road, San Marino 9, Calif. *Coleoptera.*
'40. MacSwain, J. W., 112 Agricultural Hall, Department of Entomology, University of California, Berkeley 4, Calif.
'20. McBride, O. C., Research Center, Beltsville, Md. *Insecticides.*
'43. McCall, George L., 905 Bertrand Avenue, Manhattan, Kansas. *Chemical Control of Insects.*
'29. McClure, H. Elliott, Box 292, Station A, Bakersfield, Calif. *Ecology.*
'10. McDANIEL, EUGENIA, Agricultural College, East Lansing, Mich. (F. '48). *Coccidae, Orthoptera.*
'49. MacDonald, Bruce C., 903 West Oregon Street, Urbana, Ill.
'30. McGovran, E. R., Office of Experiment Station, U. S. D. A., Washington, D. C. *Insecticides.*
'49. McKinney, Robert W., 145 Hall of Fame Terrace, Apt. 38, Bronx 53, N. Y.
'11. McINDOO, N. E., 7225 Blair Road, Takoma Park, Washington 12, D. C. (F. '34). *Insect Physiology.*
'49. Machler, K. L., Oriental Fruit Fly Investigations, Waiakoa, Maui, T. H.
'47. Magner, Marshall, 1700 S. 2nd Street, St. Louis, Mo.
'43. Maina, Bartholomew A., 10623 Church Street, Chicago, Ill. *Bombidae.*
'46. Malkin, Borys, University of Oregon, Department of Anthropology, Eugene, Oreg. *Coccinellidae.*
'40. Mangrun, James F., P. O. Box 1131, College Station, Texas. *Acarina.*
'13. *MANN, WILLIAM M., National Zoological Park, Washington, D. C. (F. '37). *Formicidae.*

'23. Manter, Jerauld A., Agricultural College, Storrs, Conn. *Economic Entomology.*
'37. Markos, Basil G., California State Dept. of Health, Bureau of Vector Control, 703 State Bldg., Los Angeles 12, Calif. *Toxicology.*
Ch. MARLATT, C. L., 1521 Sixteenth Street N. W., Washington, D. C. (F. '07, H. F. '41). *Coccidae.*
'25. Martin, Charles H., Department of Entomology, Oregon State College, Corvallis, Oreg. *Ecology, Asilidae.*
'43. Martin, Esmond B., 465 E. 57th Street, New York 22, N. Y.
'49. Martin, John C., Department of Entomology, Cornell University, Ithaca, N. Y.
'34. MARTORELL, LUIS F., Agricultural Experiment Station, P. O. Box 614, Rio Piedras, Puerto Rico. (F. '44). *Sugar Cane, Forest Insects.*
'30. Mason, Horatio C., Entomology and Plant Quarantine, Agricultural Research Center, Beltsville, Md. *Tomato Fruitworm.*
'46. Mason, William R. M., Comstock Hall, Cornell University, Ithaca, N. Y. *Ichneumonoidea.*
Ch. MATHESON, ROBERT, Cornell University, Ithaca, N. Y. (F. '28). *Ixodoidea, Culicidae.*
'49. Matthysse, John G., Department of Entomology, Cornell University, Ithaca, N. Y.
'36. Mead, Albert R., Department of Zoology, University of Arizona, Tucson, Ariz. *Chrysomelidae.*
'37. MEDLER, JOHN T., Department of Entomology, University of Wisconsin, Madison, Wis. (F. '47). *Cicadellidae.*
'25. Meiners, Edwin, Room 238, 6651 Enright, St. Louis 5, Mo. *Lepidoptera.*
Ch. MELANDER, A. L., 4670 Rubidoux Drive, Riverside, Calif. (F. '14). *Diptera.*
'27. Melvin, Roy, c/o Boyce Thompson Institute, 1086 N. Broadway, Yonkers 3, N. Y. *Physiology.*
'33. Menusan, Henry, Jr., 204 Agriculture Education Bldg., Pennsylvania State College, State College, Pa. *Physiology, Ecology.*
'49. Merker, Charles G., 1520 Cooper Street, N. S. Pittsburgh 12, Pa.
'23. Merrill, G. B., Plant Board, Seagle Bldg., Gainesville, Fla. *Coccidae, Aleyrodidae.*
'39. Metcalf, Robert L., Citrus Exp. Sta., University of California, Riverside, Calif. *Insect Physiology.*
'09. METCALF, Z. P., State College Station, Box 5215, Raleigh, N. C. (F. '34). *Homoptera.*
'35. MICHELBACHER, A. E., 112 Agricultural Hall, University of California, Berkeley 4, Calif. (F. '41). *Symphyla, Apoidea.*
'37. MICHENER, CHARLES D., Department of Entomology, University of Kansas, Lawrence, Kansas. (F. '44). *Apoidea.*
'17. MICKEL, CLARENCE E., Division of Entomology, University Farm, St. Paul 1, Minn. (F. '35). *Mutillidae.*
'36. Miller, Albert, Tulane Medical School, 1430 Tulane Avenue, New Orleans 13, La. *Culicidae.*
'31. Miller, Albert C., P. O. Drawer 2038, Pittsburgh 30, Pa. *Membracidae.*
'49. Miller, D. F., Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio.
'42. Miller, E. Morton, Box 488, Miami (University Br.), Fla. *Termites.*
'49. Miller, Howard C., 222 N. Collingwood Avenue, Syracuse, N. Y.
'46. Miller, Ralph H., Chaffey College, Euclid at 5th, Ontario, Calif.
'37. Milliron, Herbert E., P. O. Box 276, Glen Dale, W. Va. *Chalcidoidea, Bombidae.*
'29. MILLS, HARLOW B., Illinois Natural History Survey, Urbana, Ill. (F. '37). *Aptera.*
'37. MILNE, LORUS J., Department of Zoology, University of New Hampshire, Durham, N. H. (F. '47). *Trichoptera.*
'25. Milum, Vern G., 104 Vivarium Bldg., University of Illinois, Champaign, Ill. *Apiculture.*
'43. el Minchaoui, Ibrahim, c/o Societe Générale des Sucreries et de la Raffinerie d'Egypte, P. O. B. 763, Cairo, Egypt. *Sugarcane pests.*
'26. MINNICH, D. E., Department of Zoology, University of Minnesota, Minneapolis 14, Minn. (F. '39). *Behavior.*

'39. Mitchell, Robert T., Patuxent Research Refuge, Laurel, Md. *Ichneumonidae and Braconidae.*
'21. MITCHELL, T. B., State College, Raleigh, N. C. (F. '37). *Apoidea, Megachile.*
'49. Mitchell, Wallace C., Department of Entomology, Hawaii Agric. Exp. Sta., Univ. of Hawaii, Honolulu 14, Hawaii.
'22. MONTGOMERY, B. ELWOOD, Department of Entomology, Purdue University, Lafayette, Ind. (F. '31). *Odonata, Coleoptera.*
'39. Moore, George A., 359 Querbes Avenue, Outremont, Quebec, Canada. *Hemiptera.*
'49. Moore, Thomas E., 1113 West Union Street, Champaign, Ill.
'39. Moore, Warren, Raphine, Va. *Dermestidae.*
'47. Morgan, Cecil V. G., Dominion Entomological Lab., Box 30, Summerland, British Columbia, Canada. *Mites.*
'12. MORRISON, HAROLD, Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '28). *Coccidae.*
'08. MOSHER, EDNA, R. R. #1, Newport, Nova Scotia, Canada. (F. 20). *Lepidoptera.*
'20. Mote, Don C., State Agricultural College, Corvallis, Oreg. *Economic Entomology.*
'29. MOULTON, DUDLEY, 815 Santaynez Street, San Gabriel, Calif. (F. '31). *Thysanoptera.*
'49. Mowry, Paul, P. O. Box 1281, California Spray Chem. Corp., Yakima, Wash.
'15. MUESEBECK, C. F. W., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '34). *Braconidae, Bethylidae.*
'36. Mulrennan, J. A., State Board of Health, Box 210, Jacksonville, Fla. *Culicidae.*
'43. Muma, Martin H., Department of Entomology, University of Nebraska, Lincoln, Neb.
'27. *MUNRO, J. A., State College Station, Fargo, N. D. *Orthoptera, Diptera.*
'37. Munson, Sam C., Department of Biology, George Washington University, Washington 6, D. C.
'35. *MURRY, WILLIAM D., 1621 W. Houston Avenue, Visalia, Calif. (F. '46). *Sphecidae.*
'28. MUSGRAVE, ANTHONY, Australian Museum, College Street, Sidney, New South Wales, Australia. (F. '41). *Nycteribiidae.*
'27. Musgrave, Paul N., 1956 Underwood Avenue, Huntington, W. Va. *Dryopidae.*
'47. Myers, Theodore B., 1786 Gerrard Avenue, Columbus 12, Ohio.

'49. Naegele, John Adam, Department of Entomology, Cornell University, Ithaca, N. Y.
'46. Nakajima, Toshio, Entomological Institute, Fac. of Agr. Hokkaido, Sapporo, Imperial University, Japan. *Scarabaeidae.*
Ch.   NEEDHAM, J. G., 6 Needham Place, Ithaca, N. Y. (F. '07, H. F. '35). *Odonata, Ephemerida.*
'21. Neiswander, C. R., Ohio Agricultural Experiment Station, Wooster, Ohio. *Insects of Ornamentals.*
'28. Neiswander, R. B., Ohio Agricultural Experiment Station, Wooster, Ohio. *Fruit Insects.*
'39. Nesbitt, Herbert H. J., 34 Lakeside Avenue, Ottawa, Ontario, Canada. *Acarina.*
'34. Nevin, F. Reese, Plattsburg State Teachers College, Plattsburg, N. Y. *Morphology of Acarina.*
Ch.   Newcomer, E. J., Box 1291, Yakima, Wash. *Fruit Insects.*
'49. Newkirk, Maurice, Ashland College, Ashland, Ohio.
'15. Newman, George B., 246 East Hamilton Avenue, State College, Pa. *Insect Histology.*
'28. Newton, Richard C., Bureau of Entomology and Plant Quarantine, Bozeman, Mont. *Alfalfa Weevil.*
'47. Nicolaides, George, Room 844, 641 Washington Street, New York, N. Y.
'38. Nicholson, H. Page, Southeast Drainage Basins, USPHS, John Silvey Bldg., 114 Marietta Street, Atlanta 3, Ga. *Simuliidae.*

'31. Nickels, C. B., Box 209, Bureau of Entomology, Brownwood, Texas. *Pecan Insects.*
'47. Nishida, Toshiyuki, 1094 Euclid Avenue, Berkeley 8, Calif.
'22. Noble, W. B., Bureau of Entomology and Plant Quarantine, Box 1857, Sacramento 9, Calif. *Cereal and Forage Insects.*
'38. Noland, Lowell E., Biology Building, University of Wisconsin, Madison Wis.
'17. *Notman, Howard, Circle Road, Dougan Hills, Staten Island, N. Y. *Carabidae, Staphylinidae.*
'49. Nowell, Wesley Raymond, Natural History Museum, Stanford University, Calif. *Parasitic Hymenoptera.*
'37. Nye, William P., Department of Entomology, Room 225, Utah State Agri. College, Logan, Utah. *Forest Insects.*

'31. O'Byrne, Harold I., Iberia, Mo. *Ecology, Lepidoptera.*
'44. Ogloblin, Alexander, Lafinur 168, Belle Vista, F.C.N.G.S.M., Argentina.
'49. Oiticica, Jose, Filho, Division of Insects, U. S. National Museum, Washington 25, D. C.
'08. O'Kane, Walter C., Durham, N. H. (F. '24).
'29. Oman, Paul W., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '40). *Homoptera.*
'46. O'Neill, Kellie, U. S. D. A., Box 896, Macon, Ga. *Culicidae, Rhynchophora.*
'37. O'Neill, William J., Tree Fruit Branch Exp. Sta., Box 596, Wenatchee, Wash. *Fruit Insects.*
Ch. Osborn, Herbert, Ohio State University, Columbus 10, Ohio. (F. '07, H. F. '28). *Homoptera, Cicadellidae.*
'08. Osborn, H. T., Rt. 11, Box 4662, Sacramento, Calif. *Cicadellidae.*
Ch. Osburn, R. C., Department of Entomology, Ohio State University, Columbus 10, Ohio. (F. '17). *Syrphidae.*
'43. Osmun, John V., Mountain Ave., Murray Hill, N. J.
'46. Owen, Robert P., 401 Washington Avenue, Brooklyn, N. Y.
'36. Owen, William Bert, Department of Zoology, University of Wyoming, Laramie, Wyo. *Culicidae.*
'49. Owens, Virgil H., 1018 Rogers, Columbia, Mo. *Tabanidae.*
'45. Owsley, William B., Wofford College, Spartanburg, S. C. *Cerambycidae.*
'25. Ozburn, Reg. H., Ontario Agri. College, Guelph, Ontario, Canada. (F. '43). *Insect Histology.*

'15. Packard, Clyde M., Bureau of Entomology and Plant Quarantine, Washington, D. C. *Cereal and Forage Insects.*
'19. Painter, R. H., Department of Entomology, Kansas State College, Manhattan, Kans. (F. '35). *Diptera, Bombyliidae.*
'39. Palm, Charles E., Department of Entomology, Cornell University, Ithaca, N. Y. *Forage Crop Insects.*
'37. Palmer, Boyd B., Polytechnic Institute, San Germán, Puerto Rico. *Trichoptera.*
'27. Palmer, Miriam A., 621 South Howes Street, Fort Collins, Colo. (F. '37). *Aphidae.*
'47. Parfinowich, Sophy I., U. S. National Museum, Washington 25, D. C.
'27. Park, Orlando, Department of Zoology, Northwestern University, Evanston, Ill. (F. '40). *Pselaphidae.*
'39. Parker, Barbara M., Miner Laboratories, 9 So. Clinton Street, Chicago 6, Ill.
'25. Parker, H. L., European Parasite Laboratory, 58 Rue Jules Parent, Reuil-Malmaison, Seine et Oise, France. (F. '40). *Parasitic Hymenoptera.*
'24. Parker, R. L., Department of Entomology, Kansas State College, Manhattan, Kans. *Apiculture.*
'49. Parks, J. J., Trailer R-3, Laramie, Wyo.
'18. Parks, T. H., Department of Entomology, Ohio State University, Columbus 10, Ohio.
'43. Parr, Thaddeus, Whitemarsh Research Laboratory, Box 4388, Chestnut Hill P. O., Philadelphia 18, Pa.
Ch. Parrott, P. J., Agricultural Experiment Station, Geneva, N. Y. (F. '14).
'12. Parshley, H. M., Department of Zoology, Smith College, Northampton, Mass. (F. '43). *Heteroptera.*

'32. PARSONS, CARL T., Department of Zoology, University of Vermont, Burlington, Vt. (F. '46). *Coleoptera.*

'34. Parten, Herbert L., Division of Entomology, University Farm, St. Paul 8, Minn. *Greenhouse Insects.*

'32. Passos, Cyril F. dos, Washington Corners, Mendham, N. J. *Lepidoptera.*

Ch. *PATCH, EDITH M., P. O. Box 150, Orono, Me. (F. '14). *Aphididae.*

'47. Patton, Robert L., Department of Entomology, Cornell University, Ithaca, N. Y.

'35. Paullus, J. H., Midwest Division, California Packing Corp., Rochelle, Ill.

'23. *PAYNE, NELLIE M., c/o American Cyanamid Company, Boston Post Road, Stamford, Conn. (F. '40). *Physiology.*

'20. PEAIRS, L. M., Morgantown, W. Va. (F. '40).

'34. Pechuman, La Verne L., 7 Davison Road, Lockport, N. Y. *Tabanidae.*

'46. Peck, Oswald, Division of Entomology, Department of Agriculture, Confederation Bldg., Ottawa, Ontario, Canada. *Hymenoptera.*

'40. Pederson, Calvin E., Department of Entomology, Michigan State College, East Lansing, Mich. *Cicadellidae.*

'49. Pela, Albert Sylvan, Box 1615, Lubbock, Texas.

'47. Pelot, Betty Lou, University of Hawaii, 202 Gilmore Hall, Honolulu, Hawaii.

'37. Pelton, John Z., 94 E. Tulane Rd., Columbus 2, Ohio. *Aquatic Insects.*

'47. Penn, George H., III, Department of Zoology, Tulane University, New Orleans 15, La. *Diptera, Culicidae.*

'35. Penner, Lawrence R., Department of Zoology, University of Connecticut, Storrs, Conn. *Delphacidae, Muscoidea.*

'30. Pepper, Bailey B., Department of Entomology, Agri. Exp. Sta., New Brunswick, N. J. *Biological Control.*

'29. Peters, Harold T., State Teachers College, Bemidji, Minn. *Siphonaptera.*

'49. Peters, Walter P., Osborn Zoological Lab., Yale University, New Haven 11, Conn. *Morphology and Biology of Corixidae.*

'39. Peterson, Allan G., Division of Entomology, University Farm, St. Paul 1, Minn. *Potato Insects, Aphiidae, Miridae, Culicidae.*

'11. PETERSON, ALVAH, Department of Zoology and Entomology, Ohio State University, Columbus 10, Ohio. (F. '28). *Biological Control.*

'37. Peterson, Lloyd O. T., Indian Head, Saskatchewan, Canada. *Forest Entomology.*

'07. PETRUNKEVITCH, ALEXANDER, Yale University, New Haven, Conn. (F. '37). *Arachnida.*

'43. Pfadt, Robert E., Department of Entomology, University of Wyoming, Laramie, Wyo. *Orthoptera.*

'49. Philip, Cornelius B., Prin. Med. Entomologist, Rocky Mountain Lab., Hamilton, Mont.

'21. PHILLIPS, E. F., Cornell University, Ithaca, N. Y. (F. '29). *Apiculture.*

'47. Phillips, Grace R., Dept. Biology, University of Florida, Gainesville, Fla.

'12. Phillips, W. J., 718 Cargill Lane, Charlottesville, Va. *Harmolita.*

'37. Phillips, W. Levi, 985 S. 3rd Street East, Salt Lake City 4, Utah. *Lepidoptera.*

Ch. PIERCE, W. DWIGHT, Los Angeles County Museum, Los Angeles 7, Calif. (F. '30). *Rhynchophora.*

'49. Pimentel, David, Department of Entomology, Cornell University, Ithaca, N. Y.

'41. Platt, Fred R., Deputy Agri. Commissioner, Court House, Riverside, Calif. *Coccidae, Coleoptera.*

'41. Pletsch, Donald J., Division of International Health, U. S. Public Health Service, Federal Security Bldg., N., Washington, D. C. *Psyllidae, Myrmeleonidae.*

'28. PLUMMER, C. C., Apartado Number 3, Colonia Anahuac, Mexico D. F., Mexico. (F. '44). *Membracidae.*

'18. Poos, FRED W., Beltsville Research Center, Beltsville, Md. (F. '43).

'23. Porter, B. A., Bureau of Entomology and Plant Quarantine, Washington 25, D. C. *Fruit Insects.*

'43. Porter, John E., U. S. Public Health Service, P. O. Drawer 246, Miami Beach, Fla.

'49. Porter, Thomas Wayne, Department of Zoology and Entomology, Iowa State College, Ames, Iowa.

'35. Post, Richard L., Department of Entomology, University of North Dakota, Fargo, N. D. *Thysanoptera.*

'44. Potts, Robert W. L., Agri. Building, Embarcedero at Mission, San Francisco 5, Calif. *Scarabaeidae, Acaraeinae, Hymenoptera.*
'26. Potts, Samuel F., 335 Prospect Street, New Haven, Conn. *Toxicology, Physiology.*
'36. *PRATT, HARRY D., U. S. Public Health Service, District No. 6, San Juan, Puerto Rico. (F. '46). *Ichneumonidae.*
'49. Preston, Floyd W., 13009 E. Barton Rd., Whittier, Calif. *Lepidoptera, (Rhopalocera).*
'47. Pratt, John Jacob, Jr., Lab. of Insect Phys. and Toxicology, Div. of Control Investigations, Agric. Research Center, Beltsville, Md.
'16. Price, W. A., University of Kentucky, Lexington, Ky. *Economic Entomology.*
'32. *PRITCHARD, A. EARL, Division of Entomology, University of California, Berkeley, Calif. (F. '43). *Asilidae, Itonididae.*
'28. PROCTER, WILLIAM, Bar Harbor, Me. (F. '40). *Insects of Mt. Desert Region.*
'33. Putman, W. L., Dominion Entomological Laboratory, Vineland Station, Ontario, Canada. *Chrysopidae.*

'49. Quisenberry, Benson F., Department of Entomology, Kentucky Experiment Station, Lexington, Ky. *Tephritidae.*
'46. Quraishi, M. Sayeed, Fernald Hall, University of Massachusetts, Amherst, Mass.

'44. Ramos, J. A., Department of Biology, University of Puerto Rico, Mayaquez, Puerto Rico.
'42. Ramsay, Maynard J., 29 Tillman Street, Staten Island 14, N. Y. *Coleoptera, Larvae.*
'43. Rapp, William F., Jr., Gaylord Hall, Doane College, Crete, Neb. *Diptera, Psychodidae.*
'46. Redlinger, Leonard M., Entomology Dept., Kansas State College, Manhattan, Kansas. *Diptera—Empididae.*
'23. Reed, W. D., 3609 Military Road, N. W., Washington 15, D. C. *Tobacco Insects.*
'30. Rees, Don M., University of Utah, Salt Lake City, Utah. *Culicidae.*
'23. Reeves, Joseph A., 530 Federal Bldg., Buffalo 3, N. Y. *Chrysomelidae, Fulgoridae.*
'44. Reeves, William C., School of Public Health, University of California, Berkeley 4, Calif.
Ch. REHN, J. A. G., Academy of Natural Sciences of Philadelphia, 19th—The Parkway, Philadelphia 3, Pa. (F. '14). *Dermaptera, Orthoptera.*
'45. Reichart, Charles V., Department of Biology, Providence College, Providence 8, R. I. *Hemiptera.*
'43. Remington, Charles L., Osborn Zoological Lab., Yale University, New Haven 11, Conn.
'34. Rice, Paul L., Department of Entomology, Agricultural Experiment Station, Newark, Del. *Chalcidoidea.*
'30. RICHARDS, A. GLENN, JR., Entomology Department, University of Minnesota, University Farm, St. Paul 1, Minn. (F. '38). *Noctuidae.*
'14. RICHARDSON, CHARLES H., Department of Entomology, Iowa State College, Ames, Iowa. (F. '31). *Physiology.*
'29. RICHARDSON, MAJ. H. H., U.S.D.A. Quarantine Inspection Sta., 209 River Street, Hoboken, N. J. (F. '41). *Physiology.*
'46. Ricker, William J., Dominion Biol. Sta., Departure Bay, Nanaimo, British Columbia. *Plecoptera.*
'39. Riedel, F. A., 2894 Dexter Street, Denver 7, Colo.
'39. Riegel, Garland T., Department of Zoology, Eastern Illinois State College, Charleston, Ill. *Braconidae.*
'22. Ries, Donald T., Department of Biology, Illinois State Normal University, Normal, Ill. *Cephidae, Siricidae.*
'40. Riherd, Paul T., Box 461, Weslaco, Texas. *Truck Crop Insects.*
Ch. RILEY, WILLIAM A., Department of Zoology, University of Minnesota, Minneapolis, Minn. (F. '14, H. F. '49). *Parasitology.*
'49. Rindge, Frederick H., A.M.N.H., 79th and Central Park, New York, N. Y.
'33. RITCHER, PAUL O., Department of Zoology and Entomology, University of North Carolina, Raleigh, N. C. (F. '44). *Phyllophaga.*

'36. Ritchie, C. L., Box 340, Honolulu 9, Hawaii. *Coccidae, Lepidopterous Larvae.*
'47. Rivero, Juan A., Biology Department, College of Agri., Mayaquez, Puerto Rico.
'39. Roark, R. C., Bureau of Entomology and Plant Quarantine, Beltsville, Md. *Insecticides.*
'47. Roback, Selwyn S., 40 Thayer Street, New York, N. Y. *Diptera.*
'40. Roberts, H. Radclyffe, Box 490, Bryn Mawr, Pa. *Acrididae.*
'31. Roberts, J. Harvey, Box 8729, University, La. *Trichoptera.*
'43. Roberts, Reed S., 330 W. First North, Logan, Utah.
'45. Robinson, John H., 525 Beaumont Street, Greenville, Ill.
'15. Robinson, J. M., Box 671, Auburn, Ala. *Dermestidae.*
'45. Robinson, Paul Francis, 139 Union Street, Westfield, Mass.
'26. ROBINSON, WILLIAM, 653 E. Maiks Street, Orlando, Fla. (F. '39). *Physiology.*
'41. *Rockstein, Morris, Department of Zoology, Washington State College, Pullman, Wash. *Physiology, Toxicology.*
'13. Rockwood, L. P., 2138 Seventeenth Avenue, Forest Grove, Oreg. *Noctuidae, Orthoptera.*
'31. Rodeck, Hugo G., University of Colorado Museum, Boulder, Colo. *Nomada.*
'44. Rodock, Roy Edgar, Northern Idaho College of Education, Lewistown, Idaho. *Hemiptera.*
'47. Rodriguez, Juan G., Department of Entomology and Botany, University of Kentucky, Lexington, Ky.
'49. Roeder, Kenneth D., Department of Biology, Tufts College, Medford 55, Mass. *Neurophysiology and Pharmacology.*
'15. ROGERS, J. SPEED, Museum of Zoology, University of Michigan, Ann Arbor, Mich. (F. '43). *Tipulidae.*
'41. *Rogoff, William M., Department of Entomology, S. Dakota College, Brookings, S. D.
'27. ROHWER, S. A., Bureau of Entomology and Plant Quarantine, Washington, D. C. (F. '29). *Hymenoptera.*
'25. Rosewall, O. W., Box 8729, Department of Entomology, Louisiana State University, Baton Rouge 3, La. *Coleoptera, Pentatomidae.*
'49. Ross, Douglas Alexander, Comstock Hall, Cornell University, Ithaca, N. Y.
'39. Ross, EDWARD S., Department of Entomology, California Academy of Sciences, Golden Gate Park, San Francisco 18, Calif. (F. '48). *Histeridae, Embioptera.*
'31. Ross, HERBERT H., Illinois Natural History Survey, Urbana, Ill. (F. '37). *Sawflies, Caddisflies.*
'40. Roth, Louis M., Quartermaster Research & Development Laboratories, Biological Laboratories, Philadelphia Quartermaster Depot, 2800 South 20th Street, Philadelphia 45, Pa. *Diptera, Culicidae.*
'36. ROZEBOOM, LLOYD EUGENE, School of Hygiene & Public Health, 615 North Wolf Street, Baltimore 5, Md. (F. '46). *Culicidae.*
'14. RUCKES, HERBERT, 167–11 33rd Avenue, Flushing, New York, N. Y. (F. '47). *Pentatomidae.*
'39. Rude, Clifford S., Abasolo 518 Ote, Torreon, Coah., Mexico. *Ixodidae.*
'49   Ruppel, Robert F., 66 W. Northwood Avenue, Columbus, Ohio.
'46. Russell, Louise M., Bureau of Entomology and Plant Quarantine, Washington 25, D. C.
'42. Ryan, George S., R. R. #4, Angola, Ind. *Noctuidae.*

'33. *SABROSKY, CURTIS W., Division of Insects, U. S. National Museum, Washington, D. C. (F. '41). *Chloropidae.*
'41. Sailer, Reece I., Division of Insects, U. S. National Museum, Washington 25, D. C. *Hemiptera.*
'46. Sakagami, Shoichi, Entomological Institute, Hokkaido, Imperial University, Sapporo, Hokkaido, Japan.
'29. Sakimura, K., Pineapple Research Institute, Box 3166, Honolulu 2, Hawaii. *Thysanoptera.*
'46. Sallee, Roy M., 131 North Normal Street, Macomb, Ill. *Formicidae.*
'37. Sampson, William W., 156 South Fourteenth Street, Richmond, Calif. *Aphididae, Aleurodidae.*

'31. SANDERSON, MILTON W., Illinois Natural History Survey, Urbana, Ill.
(F. '43). *Phyllophaga, Staphylinidae, Chrysomelidae.*

'49. Sanjean, John, Department of Entomology, Cornell University, Ithaca, N. Y.

'07. SATTERTHWAIT, A. F., 806 Ohio Street, Urbana, Ill. (F. '30). *Calendra.*

'29. Scaramuzza, L. C., Central Mercedes, Prov. of Matanzas, Cuba. *Sugar Cane Insects.*

'49. Schatz, Leo, Department of Entomology, Cornell University, Ithaca, N. Y.

'30. Schlosberg, Morris, P. O. Box 606, West Lafayette, Ind. *Lepidoptera.*

'29. Schmidt, Carl T., Box 3166, Honolulu, Hawaii. *Ecology.*

'33. Schmidt, Helen D. O'Neil, Box 3166, Honolulu, Hawaii. *Trichoptera.*

'20. SCHMIEDER, RUDOLF G., Zoology Laboratory, University of Pennsylvania, Philadelphia, Pa. (F. '47). *Hymenoptera.*

'32. SCHMITT, JOHN B., Department of Entomology, New Jersey Agricultural Exp. Sta., New Brunswick, N. J. (F. '43). *Morphology.*

'34. Schmitt, T. J., Jr., Apt. 16, 1086 Corona Street, Denver 3, Colo. *Scolytidae.*

'47. Schoenherr, William H., P. O. Box 673, Danville, Ill.

'36. Schoof, Herbert F., 32 Wildwood Circle, S. E., Atlanta, Ga. *Chrysomelidae.*

'29. Schroeder, H. O., 5601 Patrick Henry Drive, Baltimore, Md. *Ixodoidea, Argasidae.*

'40. Schuh, Joe, P. O. Box 869, Klamath Falls, Oreg. *Odonata.*

'26. SCHWARDT, H. H., Department of Entomology, Cornell University, Ithaca, N. Y. (F. '35). *Tabanidae.*

'26. SCHWARZ, HERBERT F., American Museum of Natural History, 70th Street and Central Park West, New York, N. Y. (F. '37). *Meliponidae.*

'28. Scotland, Minnie B., 42 Continental Avenue, Cohoes, N. Y. *Lemna Insects.*

'49. Scott, H. Eldon, Division of Entomology, Science Service Bldg., Ottawa, Ontario, Canada. *Economic Entomology.*

'46. Scudder, Harvey I., Department of Entomology, Cornell University, Ithaca, N. Y. *Culicidae, Coleoptera, Lampyroidea.*

'25. SCULLEN, H. A., Department of Entomology, Oregon State College, Corvallis, Oreg. (F. '40). *Cerceridae.*

'46. Seabrook, Edwin L., County Courthouse Annex, West Palm Beach, Fla.

'23. Seamans, H. L., 616 Confederation Bldg., Ottawa, Ontario, Canada. *Muscoidea.*

'41. Sears, Jack W., B. L. 319, University of Texas, Austin 21, Texas.

'36. SEEVERS, CHARLES H., Roosevelt College, 420 South Michigan, Chicago 5, Ill. (F. '46). *Termitophiles, Staphylinidae (Aleocharinae).*

'38. Seamans, Frank M., Department of Biology, Morningside College, Sioux City, Iowa. *Economic Entomology.*

'08. SEVERIN, H. C., South Dakota State College, Brookings, S. D. (F. '39). *Orthoptera, Homoptera, Heteroptera.*

'07. SHAFER, GEORGE D., 321 Melville Avenue, Palo Alto, Calif. (F. '41). *Physiology.*

'46. Sharp, S. S., Pest Control Research, E. I. DuPont de Nemours & Co., Wilmington 98, Del. *Toxicology.*

'35. SHAW, FRANK R., Fernald Hall, Massachusetts State College, Amherst, Mass. (F. '46). *Mycetophilidae.*

'29. Shaw, John G., Laboratorio Entomologico, Apartado Postal #28561, Tacuba 17, D. F., Mexico.

Ch. SHELFORD, V. E., Vivarium Building, Wright and Healy Streets, Champaign, Ill. (F. '20). *Ecology.*

'43. Shenefelt, Roy D., Department of Entomology, University of Wisconsin, Madison 6, Wis.

'22. SHEPARD, HAROLD H., Insecticide Testing Laboratory, U.S.D.A., Beltsville, Md. (F. '39). *Hesperiidae.*

'11. SHERMAN, JOHN D., JR., 132 Primrose Avenue, Mt. Vernon, N. Y. (F. '39). *Dytiscidae.*

'34. Shields, S. E., 346 Berry Field, Nashville, Tenn. *Culicidae.*

'35. *Shockley, Wilfred, 1180 Sherman Street, Denver 3, Colo. *Cerambycidae, Decticinae.*

'28. Shropshire, Leslie H., Box 215, DeWitt, Iowa.

Ch. SHULL, A. FRANKLIN, 431 Highland Road, Ann Arbor, Mich. (F. '39). *Aphididae.*

'42. Simmonds, Frederick J., Imperial Parasite Service, Belleville, Ontario, Canada.

'29. Simmons, Perez, 712 Elizabeth Street, Fresno 3, Calif. *Dried Fruit Insects.*

'39. Simonds, William E., Star Route, Box 87, Aguanga, Calif. *Elateridae.*

'30. *Simpson, Geddes W., Room 306, Plant Science Bldg., Orono, Maine. *Insects and Plant Diseases.*

'38. Singleton, J. M., Room 2003, 2 Park Avenue, New York 16, N. Y. *Quarantines.*

'46. Slater, James A., Department of Zoology and Entomology, Iowa State College, Ames, Iowa. *Lygaeidae.*

'43. Slifer, Eleanor H., Department of Zoology, State University of Iowa, Iowa City, Iowa.

'32. Smith, Carroll N., 11 Vanderbilt, Orlando, Fla. *Ixodidae.*

'32. Smith, Charles E., Agricultural Exp. Sta., University Branch, Baton Rouge, La. *Truck Crop Insects.*

'35. SMITH, CLYDE F., Department of Entomology, University of North Carolina, Raleigh, N. C. (F. '46). *Aphididae.*

'27. SMITH, FLOYD F., Agri. Research Center, Beltsville, Md. (F. '43). *Aphididae, Tarsonemidae.*

'41. Smith, Gordon F., P. O. Box 907, Bakersfield, Calif. *Diptera.*

'35. Smith, Howard W., Department of Entomology, Purdue University, Lafayette, Ind.

'37. Smith, Marion E., Fernald Hall, Massachusetts State College, Amherst, Mass. *Arctiidae.*

'19. SMITH, MARION R., Room 377, U. S. National Museum, Washington 25, D. C. (F. '38). *Formicidae.*

'42. Smith, Ray F., 112 Agriculture Hall, University of California, Berkeley 4, Calif. *Diabrotica, Colias.*

'14. SMITH, ROGER C., Department of Entomology, Kansas State College, Manhattan, Kans. (F. '31). *Neuroptera.*

'18. Snapp, Oliver I., Box 527, Fort Valley, Ga. *Rhynchophora.*

'39. Snipes, B. Thomas, 1020 Bonnie Brae Blvd., Denver 9, Colo. *Siphonaptera.*

'24. SNODGRASS, R. E., 3706 Thirteenth Street, N. W., Washington 10, D. C. (F. '27, H. F. '49). *Morphology.*

'45. Snow, Willis E., The Principia, College of Liberal Arts, Elsah, Ill.

'44. Snyder, Everett G., Department of Biological Science, Michigan State College, East Lansing, Mich. *Diptera, Morphology and Economic Entomology.*

'36. Snyder, Fred M., Entomology Section, Med. Div. Army Chem. Center, Md. *Muscoidea.*

'49. Soliman, Abdel-Aziz Abdel-Hafez, Department of Entomology, University of Minnesota, St. Paul, Minn.

'38. Sommerman, Kathryn M., Dept. of Parasitology, AMDRGS, Army Med. Center, Washington 12, D. C. *Corrodentia.*

'14. *Spencer, G. J., University of British Columbia, Vancouver, British Columbia, Canada. *Trypetidae.*

'19. SPENCER, HERBERT, Box 112, Fort Pierce, Fla. (F. '37). *Hymenoptera, Citrus Insects.*

'49. Spieth, Herman T., Department of Zoology, University of Texas, Austin Texas.

Ch. SPOONER, CHARLES S., Box 102, McLean, Va. (F. '43). *Fulgoridae.*

'49. Stafford, E. W., State College, Miss.

'30. Stanley, W. W., Agricultural Exp. Sta., Knoxville, Tenn. *Phalaenidae.*

'46. *Stannard, Lewis J., Jr., Illinois Natural History Survey, Urbana, Ill. *Thysanoptera.*

'35. Stehr, William C., Department of Zoology, Ohio University, Athens, Ohio. *Coccinellidae, Carabidae.*

'27. Steiner, L. F., P. O. Box 2280, Fruit Fly Laboratory, Honolulu, Hawaii. *Fruit Insects.*

'46. Steinhaus, Edward A., Insect Pathology Laboratory, University of California, Berkeley 8, Calif.

'29. Steinweden, John B., Bureau of Nursery Service, State Department of Agriculture, Sacramento, Calif. *Coccidae, Thysanoptera.*

'31. STEWART, M. A., Division of Entomology, 112 Agriculture Hall, University of California, Berkeley, Calif. (F. '41). *Siphonaptera.*
'49. Steyskal, George C., 27253 West River Road, Grosse Ile, Mich. *Diptera.*
'15. Stiles, Charles F., Box 29, Stillwater, Okla.
'23. Stirrett, George M., Dominion Entomological Laboratory, Chatham, Ontario, Canada.
'38. Stitt, Loyd L., Western Washington Experiment Station, Puyallup, Wash. *Miridae.*
'27. STONE, ALAN, Bureau of Entomology and Plant Quarantine, Washington 25, D. C. (F. '40). *Simuliidae, Tabanidae, Culicidae.*
'36. Stone, Philip C., 105 Whitten Hall, University of Missouri, Columbia, Mo. *Ixodidae.*
'28. Stone, William E., Laboratorio Entomologica, Apartado Number 3, Colonia Anhuac, D. F., Mexico.
'42. Strandtmann, R. W., Department of Biology, Texas Technological College, Lubbock, Texas. *Specidae, Acarina: Laelaptidae.*
'12. Strickland, E. H., Main Library, University of Alberta, Edmonton, Alberta, Canada. *Elateridae.*
'25. Strohecker, H. F., Department of Zoology, University of Miami, Coral Gables 34, Fla. *Orthoptera.*
'34. Strom, L. G., Box 992, USPHS, Brownsville, Texas. *Aphiidae.*
'46. Strong, Rudolph G., P. O. Box 1538, State College, Miss.
'49. Stroud, Clyde P., P. O. Box 1103, Santa Fe, N. M.
'49. Summers, Francis M., Department of Entomology, University of California, Davis, Calif. *Economic Entomology, Acarology.*
'23. SWEETMAN, HARVEY L., State College, Amherst, Mass. (F. '43). *Ecology.*
'49. Swain, Ralph B., 406 Park Avenue, East Orange, N. J. *Quarantine Entomology.*
'20. SWEZEY, OTTO H., 2044 Lanihuli Drive, Honolulu 14, Hawaii. (F. '30). *Delphacidae, Lepidoptera.*
'44. Swift, Hewson H., 535 W. 113th St., New York 25, N. Y. *Araneida, Ichneumonidae.*

'46. Takahsi, Hirosi, Entomological Institute, Hokkaido Imperial University, Sapporo, Japan. *Simuliidae and Tabanidae.*
'37. Talbot, Mary, Lindenwood College, St. Charles, Mo. *Formicidae.*
'47. Tanada, Yoshinori, 511 Hiram Lane, Honolulu 22, T. Hawaii.
'36. Tanner, M. C., 2902 Jackson Avenue, Ogden, Utah. *Plecoptera.*
'27. TANNER, VASCO M., Brigham Young University, Provo, Utah. (F. '46). *Tenebrionidae, Carabidae.*
'36. *TAUBER, OSCAR E., Department of Zoology, Iowa State College, Ames, Iowa. (F. '47). *Physiology.*
'47. Taylor, Earl J., Box 512, Davis, Calif.
'22. Taylor, Leland H., Department of Botany, West Virginia University, Morgantown, W. Va. *Aculeate, Hymenoptera.*
'34. *Telford, Horace S., Department of Zoology, Washington State College, Pullman, Wash. *Syrphidae.*
'40. Thatcher, T. O., Department of Entomology, Colorado A. & M. College, Fort Collins, Colorado. *Scolytidae, Buprestidae, Cerambycidae.*
'21. Thomas, Charles A., State College Laboratory, Kenneth Square, Chester County, Pa. *Elateridae, Scarabaeidae.*
'32. THOMAS, EDWARD S., Ohio State Museum, Ohio State University, Columbus 10, Ohio. (F. '46). *Orthoptera.*
'38. Thomas, Henry D., North Park College, Foster and Kedzie, Chicago 25, Ill.
'15. Thomas, F. L., Agricultural Exp. Sta., College Station, Texas. *Cotton Insects.*
'49. Thompson, Robert K., 69 E. Lane Avenue, Columbus 1, Ohio. *Culicidae (Host Attraction).*
'39. Thompson, W. L., Box 1074, Lake Alfred, Fla. *Citrus Insects.*
'10. THOMPSON, W. R., 228 Dundas Street, Belleville, Ontario, Canada. (F. '27). *Tachinidae.*
'47. Thornton, Dorothy Golden, Forest Insect Laboratory, Agricultural Research Center, Beltsville, Md.

'46. Thurman, Deed C., Jr., School of Public Health, University of California, Berkeley, Calif. *Culicidae.*

'47. Thurman, (Mrs.) Ernestine B., Bureau of Vector Control, 2180 Milvia Street, Berkeley, Calif.

'22. TIETZ, HARRISON M., Department of Zoology, Pennsylvania State College, State College, Pa. (F. '46). *Noctuidae.*

'11. TIMBERLAKE, P. H., Citrus Exp. Sta., Riverside, Calif. (F. '38). *Encyrtidae.*

'23. TISSOT, A. N., Agricultural Exp. Station, Gainesville, Fla. (F. '48). *Aphididae.*

'26. Todd, F. E., c/o University of Arizona, Tucson, Ariz. *Apiculture.*

'33. *TOWNES, HENRY K., JR., Department of Zoology and Entomology, North Carolina State College, Raleigh, N. C. (F. '43). *Ichneumonidae, Chironomus.*

'28. Townsend, Lee H., Department of Entomology, University of Kentucky, Lexington, Ky. *Neuroptera.*

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PREPUPAL CHANGES IN THE VENTRICULAR EPITHELIUM OF THE EUROPEAN CORN BORER, PYRAUSTA NUBILALIS (HUBN.)[1]

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University of Wisconsin

An investigation of the digestive epithelium of the European corn borer during the winter diapause was carried out in conjunction with nutrition and food habit studies of the larvae of this insect. Histological changes associated with metamorphosis were observed at the onset of diapause, and the study became one of tracing the prepupal changes in the epithelium of the mid-gut. The European corn borer passes the winter as a mature larva in diapause. The larva pupates in the spring without further feeding. The use of the overwintering generation of larvae for studies of prepupal changes has an advantage in that the rate of the developmental changes that occur is greatly retarded by the low environmental temperatures. The several phases of metamorphosis are therefore more distinctly separate than is the case with the generation which matures and pupates during the summer. The observations reported here were repeated in studies of the histological changes associated with metamorphosis in larvae which pupated during the summer, and the same developmental changes were found to occur.

Considerable literature is available on the histology and cytology of the mid-gut of lepidopterous larvae. However, relatively little has been published on the histological and cytological changes in the mid-gut during metamorphosis. In a classic work on this subject, Deegener (1908) described metamorphosis of the digestive tract of *Malacosoma castrensis* in great detail. Ito (1920) studied the metamorphosis of the digestive tract of *Bombyx mori*. As far as the mid-gut

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was concerned, Ito's observations were in complete accord with those of Deegener.   Henson (1930) published on the early mid-gut development of *Vanessa urticae* and the late (fifth instar) mid-gut development of *Pieris brassicae*.   Although Henson did not carry the study unto the pupal stages, his observations on the prepupal stages in *Pieris* were in agreement with those of Deegener.

The only paper known to the writers which is devoted to the anatomy of the mid-gut of the European corn borer is that of Buchmann (1928), in which the development and secretory activity of the epithelial cells was traced from the first to the last (fifth) instar, but in which no account of changes associated with metamorphosis was given.

MATERIAL AND METHODS

The larvae utilized in this study were collected from the field at regular intervals from early fall until pupation was nearly complete in the spring.   Immediately after collection, the larvae were fixed in Bouin's fixative at 65° C.   The warm Bouin's was injected into the hemocoel, after which the larvae were dropped into the warm fixative. The fixative was then brought to room temperature.   After about twenty-four hours in this solution, the digestive tracts were removed by dissection and rinsed in 70% ethyl alcohol until the yellow color of the fixative was no longer evident.   They were then dehydrated by the n-butyl alcohol method of Stiles (1934) and imbedded in paraffin. Serial sections were stained with Heidenhain's iron-haematoxylin and counterstained with Fast Green FCF.

In the case of the histochemical methods employed, the above procedure was modified as necessary.   For the detection of fat, the larvae were fixed in cold calcium-formol according to the technique of Baker (1946).   The tissue was sectioned in a frozen state and stained with Sudan Black.   For the detection of glycogen, the larvae were fixed in a solution consisting of nine parts of a saturated alcoholic solution of picric acid and one part of formalin.   The paraffin sections were stained with Best's carmine by the method given by Conn and Darrow (1946). Uric acid in the tissues was detected by the technique of Hollande (1931) in which the tissue is fixed in the dark with a solution of silver nitrate and neutral formalin.   Paraffin sections were either left unstained or were stained lightly with haemalum and eosin.

RESULTS

The epithelium of the ventriculus of the immature last instar larvae of the European corn borer appeared to be quite typical of the condition reported in the literature for lepidopterous larvae in general and by Buchmann (1928) for *Pyrausta*.   Figure 1 is a photomicrograph of the ventricular epithelium of a feeding larva.   The mucosa consists of tall columnar cells with prominent striated borders, and numerous goblet cells.   Regenerative cells are scattered singly or in small groups along the distinct basement membrane.   Although it is not shown in figure 1, a peritrophic membrane was always present in feeding larvae.

At larval maturity, feeding ceased and the gut tract was evacuated of ingesta and peritrophic membrane.   At this time, or slightly earlier,
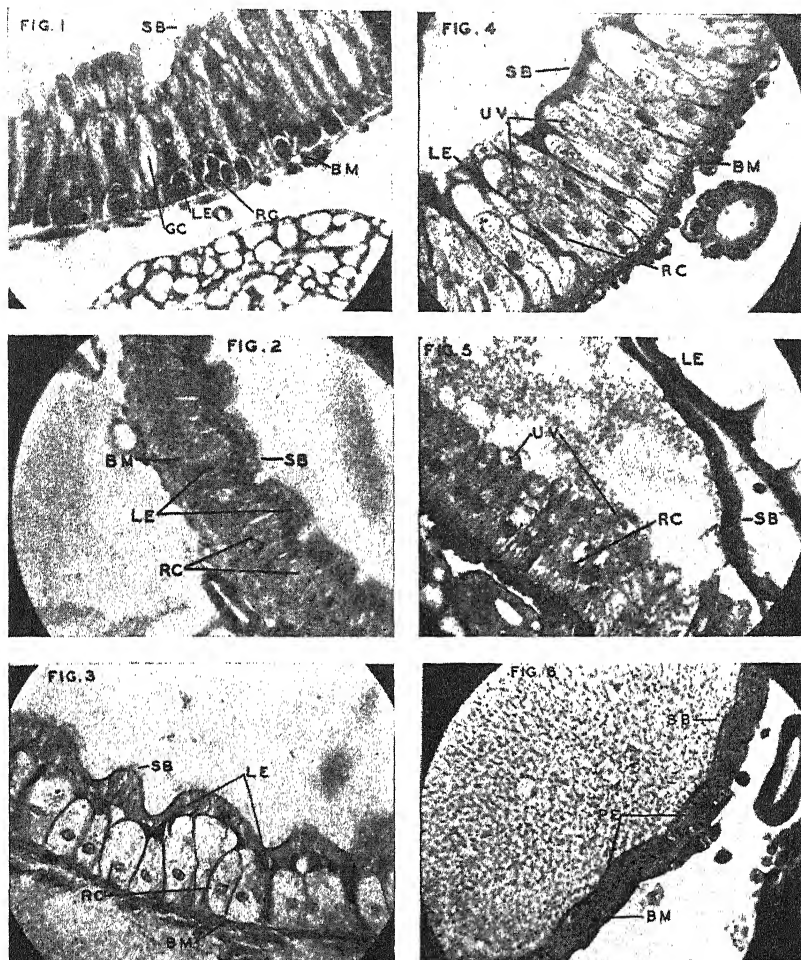
FIG. 1. Mucosa of the ventriculus of an immature last instar European corn borer larva. FIG. 2. Mucosa of the ventriculus of a mature last instar European corn borer larva shortly after feeding ceased. FIG. 3. Mid-winter mucosa of the ventriculus of a European corn borer larva. FIG. 4. Early prepupal mucosa of the ventriculus of a European corn borer. FIG. 5. Ventricular mucosa of late prepupa or early pupa of the European corn borer. FIG. 6. Early pupal ventricular epithelium of the European corn borer.

ABBREVIATIONS USED IN FIGURES

BM—Basement membrane.
GC—Goblet cell.
LE —Larval digestive epithelium.
PE —Pupal ventricular epithelium.

RC—Regenerative cell.
SB —Striated border.
UV—Urate vacuole.

the regenerative cells began to enlarge and became very prominent. No mitotic figures were observed, and the apparent increase in regenerative cells was interpreted as being solely in cell size, rather than in both size and number. Figure 2 shows the early stages of this process. It can be observed in this figure that the enlarged regenerative cells became round and that their cytoplasm did not stain as deeply as did the cytoplasm of the columnar cells. Goblet cells were no longer detectable, but the striated border remained visible. The larval digestive epithelium showed no evidence of secretory activity at this or any subsequent stage. The basement membrane was still present, although the "connective tissue" observed by Deegener (1908) appeared to have been formed. The basement membrane did not disappear as observed by Deegener in *Malacosoma*. That the enlarged cells were the original regenerative cells was indicated by two observations: (1) the complete disappearance of the small basal cells as the layer of enlarged cells became more prominent, and (2) the appearance of all intergradations between unmodified regenerative cells and the large cells during the early stages of the process.

The enlargement of the regenerative cells continued until a continuous layer of the large, lightly staining rounded cells was formed. Figure 3 shows a typical section at this stage. The striated border of the larval digestive epithelium remained prominent. The nuclei of the latter cells began to show signs of pyknosis in some areas. The larval digestive cells are shown to be much crowded and reduced, but it was observed that they retained their connections to the basement membrane. This is shown in figure 3 by the thin strands of cytoplasm extending between the regenerative cells and to the basement membrane This was found to be the typical stage in which the larvae passed the winter. No further changes were detected until activity was resumed in the spring.

The observations made on the larvae during the mid-winter stage are not in strict agreement with those of the earlier workers. Ito (1920) reported the larval digestive epithelium of *Bombyx* to have lost its striated border at about this point. However, the present writers found that in the corn borer larva the striated border was maintained until well after the larval digestive epithelium was sloughed off into the lumen (see figure 5). Deegener (1908) with *Malacosoma* and Ito (1920) with *Bombyx* described the early appearance of an extensive irregular vacuole layer between the larval digestive epithelium and the layer of enlarged regenerative cells. Deegener considered the vacuoles as being from both cell layers, but Ito implied that they arose from the basal portions of the digestive epithelium. Deegener observed that the vacuolar layer was probably the only factor holding the larval digestive epithelium and the regenerative cells together, and that when the vacuoles later ruptured, the two cell layers separated. In the corn borer larvae vacuoles of this type were not observed, and the digestive epithelial cells remained attached to the basement membrane until they were cast off into the gut lumen. Both Deegener and Ito observed a dissolution and reformation of the basement membrane; whereas, the present writers did not observe this phenomena in the European corn borer.

Histochemical tests for stored fat and glycogen in the regenerative cells during the winter stage were inconclusive. Fat droplets were detected in the cells, but not in quantities sufficient to indicate positively that fat was being stored. Glycogen tests were largely negative, although a little glycogen was found in some of the cells.

Further histological changes in the mid-gut epithelium became apparent during the early spring. The regenerative cells lost their rounded or polyhedral form and increased in height to become tall columnar cells. Shortly after the development of the columnar form, a vacuole developed in the apical region of each cell. Figure 4 depicts the situation at this stage. The deeply staining granular inclusions of the apical vacuoles were identified histochemically as uric acid or urates. These apical urate vacuoles were referred to as extraneous nuclei by Deegener (1908).

As development proceeded, the vacuoles became larger and more distinctly apical, until they projected from the distal ends of the cells as prominent bulb-like formations. The vacuoles began to burst and the larval digestive epithelium began to slough off to form the so-called yellow body. In many regions of the gut, the larval epithelium was cast off before the vacuoles burst. Figure 5 shows the beginning of the vacuole rupturing stage. The granular material in the gut lumen was not evident until the urate vacuoles began to rupture. The dissolution of the yellow body was probably enzymatic, since no invasion by phagocytes was observed. It is very likely that any enzymes present were formed by the regenerative cells, although probably not in the urate vacuoles. At the stage shown in figure 5, the larvae were in the characteristic prepupal posture.

After the beginning of the vacuolar disintegration, the nuclei of the regenerative cells moved toward the cell bases. The cytoplasm of the cells continued to pour out into the lumen, until the cells were only about one-fourth of their original height. In some areas the entire cell layer appeared to be lost, but in most regions the nuclei and a thin cytoplasmic layer were not lost, and the cells began to repair. The cells, now of a low cuboidal type, reformed their distal cell walls and developed a striated border. Figure 6 shows a typical section at this stage. It was observed that the previously convoluted basement membrane became straightened out, as a result of which the cross-section diameter of the gut was increased considerably. This increase in diameter probably was due to the bulk of the granular mass secreted into the lumen by the cells. At the time of pupation the mid-gut epithelium was in about the state of development shown in figure 6. From this low cuboidal pupal epithelium, the imaginal epithelium is presumed to arise.

<div align="center">SUMMARY</div>

The prepupal changes in the mid-gut epithelium of both the summer and the over-wintering generations of the European corn borer may be summarized as follows:

1. The regenerative cells of the larval ventricular mucosa enlarge to form a continuous layer.

2. The regenerative cells become columnar and develop apical vacuoles containing uric acid or urates.

3. The larval digestive epithelium is cast off into the gut lumen.

4. The distal portions of the regenerative cells disintegrate into the lumen.

5. The nuclei and basal portions of the regenerative cells form a low cuboidal pupal epithelium with a distinct striated border.

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THE SOCIETY OF SYSTEMATIC ZOOLOGY

The Society of Systematic Zoology, formed in 1948, is the result of recognition of the need for a means of bringing taxonomists together to represent their interests among zoologists in general, and to improve taxonomic practice and training through united action. That taxonomists see the advantage to such association is attested by the fact that more than 700 have joined the Society during its three years of existence. At the present rate of growth the goal of 1000 members should easily be met in 1951.

The history and projects of the Society have been outlined in its News Letter No. 2, published in March 1950. Its logical field of activity includes all the systematic fields of zoology and paleontology, and all persons interested in any way in systematics or any of the related fields will be welcomed to membership.

Among the projects in preparation or under consideration by the Society are an advanced textbook of the principles of systematics, a journal of the principles of systematic zoology, studies of the current practices and needs of teaching in taxonomy, improving publication outlets for systematic papers, preparation of faunal handbooks to fill gaps in the present literature, cooperation with the Zoological Record, standardization of practices and terminologies, sponsoring of annual meetings for personal contact and presentation of papers, an identification service, representation on the American Association for the Advancement of Science, the American Institute of Biological Sciences, the National Research Council, and similar organizations, and sponsoring group opinion on such problems as microfilm publication of new names, the copyright of the publications of the International Commission on Zoological Nomenclature, and the international nomenclature situation.

Entomologists were not among the groups most widely reached by the early announcements. Their full participation, however, is essential to full influence of the Society and they are cordially invited to join. Address inquiries to Dr. C. Clayton Hoff, (Chairman of the Membership Committee), University of New Mexico, Albuquerque, New Mexico.

BRONTISPA YOSHINOI BARBER, A DESCRIPTION OF ADULT AND IMMATURE STAGES[1]

(Coleoptera: Hispidae)

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The coconut pest from the Palau Islands, *Brontispa yoshinoi* Barber, was first recorded by Chujo (1937) who misidentified it as *Planispa chalybeipennis* (Zacher). Later Esaki (1940) recognized this Palauan insect as an undescribed blue species of the genus *Planispa*.

Apparently the same species was observed by Oakley (1946) who states: "? *Brontispa* sp., a blue colored hispine beetle feeding on leaflets in the crown was taken from coconuts on both Babelthuap and Peleliu. Its type of injury to coconuts was similar to that of *Brontispa mariana* Spaeth in Truk and the Marianas, in that it attacks newly exposed leaf tissue and leaves a frond soon after it is fully spread. Attacks of the pest in the Babelthuap locality surveyed seemed light and insignificant, but perhaps 10 per cent of the palms in a Peleliu planting showed some sign of infestation with an occasional palm being seriously affected."

The junior author conducted a survey in 1948 for the Pacific Science Board of the National Research Council and found *B. yoshinoi* to be generally distributed over southern Babelthuap, Koror, Arakabasan, and Peleliu Islands. The most severe damage to palms was noted on Peleliu and the infestation was greater than that described by Oakley (1946). The beetle apparently has habits nearly identical with *B. mariana*, a species which has not been found in the Palau group although it occurs throughout the Caroline islands lying to the north and east. In the Palau Islands its ecological niche is nicely filled by *B. yoshinoi*.

Brontispa yoshinoi Barber
(Figs. 1–17)

Planispa chalybeipennis, Chujo (not Zacher, 1915), 1937, Trans. Nat. Hist. Soc. Formosa, 27: 227, figs. 5, 6, 7, 9. (Misidentification.)
Brontispa chalybeipennis, Lepesme (not Zacher, 1915), 1947, Les Insectes des Palmiers, p. 545. (In part misidentified.)

Male.—Form elongate, four times longer than wide, subparallel sided, depressed, shining; head, pronotum, scutellum piceous; elytra deep metallic blue, extreme apices brown; abdomen fuscous. *Head* (fig. 1) above as long as wide including anterior projection, from beneath 1.6 times longer than wide, nearly half the width of pronotum; elevated interocular area wider than long (36:27) excluding anterior process, width greatest at base, tapering slightly toward anterolateral angles,

the latter feebly dilated with pointed apices projecting laterally, anterior margin of interocular area feebly obliquely arcuate with elongate process arising from middle and extending anteriorly between basal antennal segments, interocular surface with distinct, deep, median longitudinal sulcus sinuately outlined, widest at anterior margin, constricting posteriorly then expanding at middle and finally constricting so sides of sulcus nearly contiguous at base, elevated surface adjacent to sulcus coarsely, irregularly punctate, approaching rugosity, finely rugulose laterally and anteriorly; inter-antennal process narrow, about two and one-half times as long as width at base, nearly as long as first antennal segment, sides subparallel, feebly accuminate, narrowing anteriorly, terminating into broadly rounded apex, margins entire, upper surface with deep sulcus continuing from interocular structure, widest at base, narrowing gradually toward apex, outlined by vertical side margins, surface of sulcus very finely reticulate, deepest anteriorly; interocular area (clypeus) beneath slightly elevated, with surface rather coarsely, shallowly punctate and microscopically reticulate, clothed with abundant fine erect brownish pubescence confined to elevated plateau; antennae slightly longer than head and thorax combined, distinctly shorter than one-third length of body, dark brown above, paler beneath, first segment longest and broadest, nearly twice as long as broad, second shortest, third slightly longer, first segment as long as second and third combined, four to six subequal in length, seventh longest of flageller segments, four distal segments feebly compressed laterally, clothed with very short appressed pile confined to dorso-ventral surfaces (appearing striped); mandibles blunt, bidentate, incisor tips slightly overlapping (fig. 7). *Pronotum* (fig. 1) very slightly longer than wide (45:42), length equal to width of elytra at base; sides nearly parallel from base to cephalic third thence expanded, forming rounded more or less projecting anterolateral angles, widest at this point, each posterolateral angle bearing carina-like tooth at margin projecting more or less laterally, lateral pronotal margins sharp, each inner angle of anterolateral projection bearing single small rounded tooth, anterior margin extending between latter teeth broadly rounded and convex; upper surface very sparsely and finely punctate, with large scattered conspicuous punctures becoming most numerous on lateral areas at front and fewer on posterior lateral areas, absent on anterior convex surface, rather sparse on disc; inflexed sides finely reticulate with few very large, deep punctures restricted more or less to anterior half; prosternal disc glabrous, sparsely finely punctate; mesosternum with somewhat larger punctures than on preceding structure and with several shallow feeble longitudinal impressions at middle; metasternal sculpturing similar to prosternal disc. *Scutellum* triangular with sides slightly curved outwardly, surface microscopically reticulate, base depressed. *Elytra* three times as long as wide; base bisinuate, wider than base of pronotum; humeri broadly rounded, exposed; sides subparallel, feebly sinuate being slightly constricted near basal third, thence slightly divergent posteriorly and very feebly arcuate reaching widest point just behind middle, then gradually and arcuately convergent to apex in apical fourth, margins sharp; apices (fig. 8) truncate, truncature very feebly inwardly oblique toward the very slightly projecting subspinose sutural angles, limited
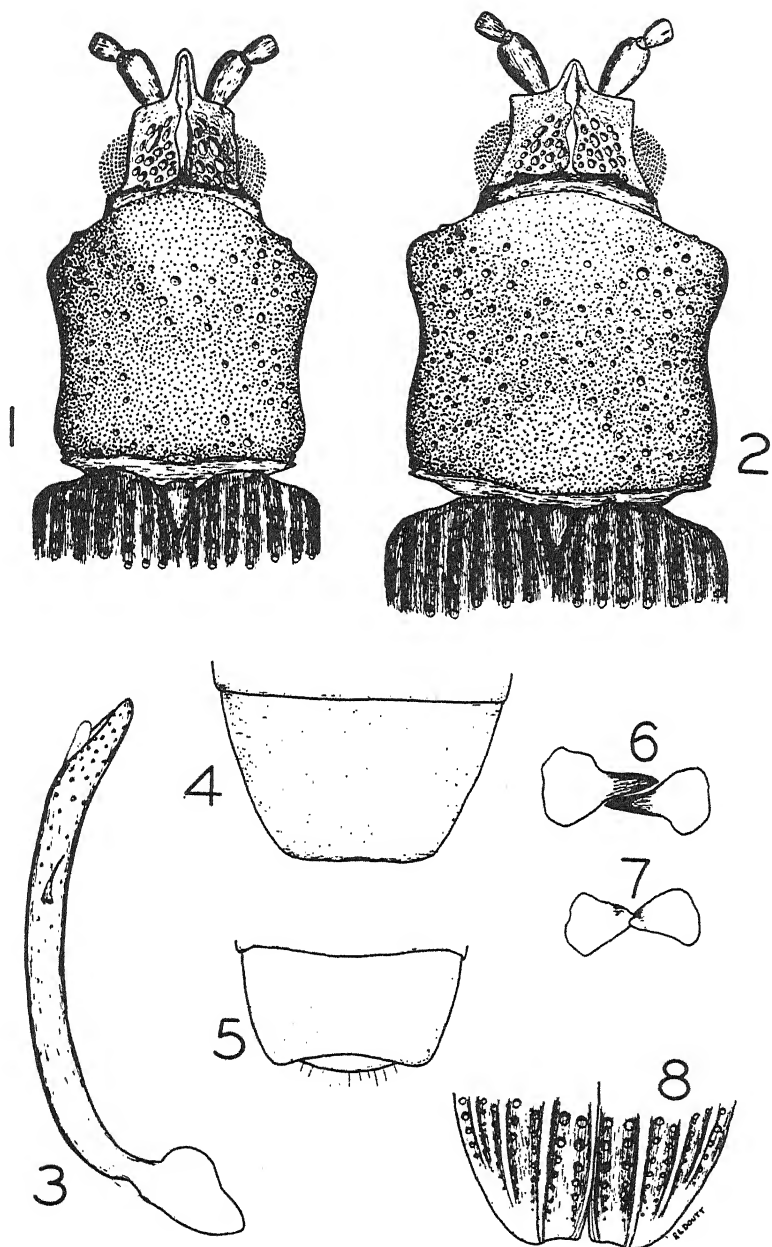
Brontispa yoshinoi Barber, morphological characters of adults. FIG. 1. Dorsal view of ♂ head and pronotum. FIG. 2. Dorsal view of ♀ head and pronotum. FIG. 3. Lateral view of ♂ genitalia. FIG. 4. Ventral view of ♀ fifth abdominal sternite. FIG. 5. Ventral view of ♂ fifth abdominal sternite and of pygidial apex. FIG. 6. Mandibles of *Brontispa mariana* Spaeth. FIG. 7. Mandibles of *B. yoshinoi*. FIG. 8. Dorsal view of elytral apices showing costae and apical truncature.

laterally at junction of median longitudinal elytral costae with apical margin; surface glabrous, punctate-striate, punctures large, deep, with interstices on disc more or less equidistant, each elytron bearing nine rows, including scutellar and marginal rows on sub-basal area, postbasal area with eight rows excluding scutellar row, surface slightly behind middle with ten rows, sixth and seventh rows commencing near middle terminating near apical fifth, in apical area rows converging; apical area with distinct costae (fig. 8) appearing near origin of apical declivity, each elytron with a sutural, medial and two lateral costae, sutural and medial costae attaining apical margin. *Metathoracic wings* slightly longer than elytra when apices unfolded. *Legs* largely pale brown, femora distally darker; each trochanter bearing single more or less erect seta arising near pointed apex; each anterior femur armed with small, blunt carina-like tooth near base; each anterior tibia with oblique broad groove, near apex, margins of sulcus raised, appearing tooth-like, sulcus clothed with golden pile and accepts femoral tooth in tibial retraction. *Abdomen* in dissected paratopotypes with tergites sclerotized, surface finely reticulate with violaceous blue metallic luster; pygidium not exposed from above in natural repose, transverse, with apical margin broadly rounded, upper surface coarsely rather densely punctate, each large puncture with a rather long semi-erect seta projecting posteriorly, more abundant and stouter apically, thus apices of projecting setae visible from beneath; sternites glabrous, finely reticulate, particularly laterally, punctuation very fine and sparse; fifth sternite (fig. 5) as long as preceding sternite measured at middle, with apical margin broadly, arcuately emarginate, emargination limited laterally at postero-lateral angles, surface with somewhat more dense and coarse punctures than preceding sternites. *Genitalia* (fig. 3) from paratopotype.

Length, 7.9 mm; *width,* 1.8 mm.

Female.—Differs from male externally by the following characters: Form slightly larger throughout, not quite four times as long as wide; *head* (fig. 2) with interantennal projection shorter, only half the length of basal antennal segment, base wider, sides more rapidly acuminate terminating in very narrowly rounded apex, appearing pointed with little magnification; elevated *interocular area* much wider than long (40:25); *pronotum* (fig. 2) as long as wide; *elytra* not quite three times as long as wide, more dilated just behind middle; *abdomen* with fifth sternite (fig. 4) slightly longer than preceding sternite, apical margin apparently truncate but perceptibly very feebly broadly arcuately emarginate.

Length, 9.0 mm; *width,* 2.3 mm.

Variations.—Form rather constant, color of antennae, scutellum, legs and abdominal sternites varying from brown to piceous, at times pronotum fusco-piceous at sides; interantennal projection in males (viewed laterally) with apex varying from nearly parallel with the longitudinal axis to distinctly curved upward at about a 20° angle, apical margin varying from rather narrowly rounded to broadly rounded; pronotal punctuation variable, at times more dense on disc; clypeal pubescence absent in several paratopotypes (rubbed ?).

Length, ♂♂ 7.0-8.3 mm; ♀♀ 7.7-9.5 mm.
Width, ♂♂ 1.6-1.8 mm; ♀♀ 1.8-2.3 mm.

Sexual dimorphism.—As already described, the length of inter-antennal process and the shape of the apical margin of the fifth abdominal sternite are sexually dimorphic, and these particular characters were constant within the series studied. An additional secondary sexual character which appears to be rather constant is the elytral
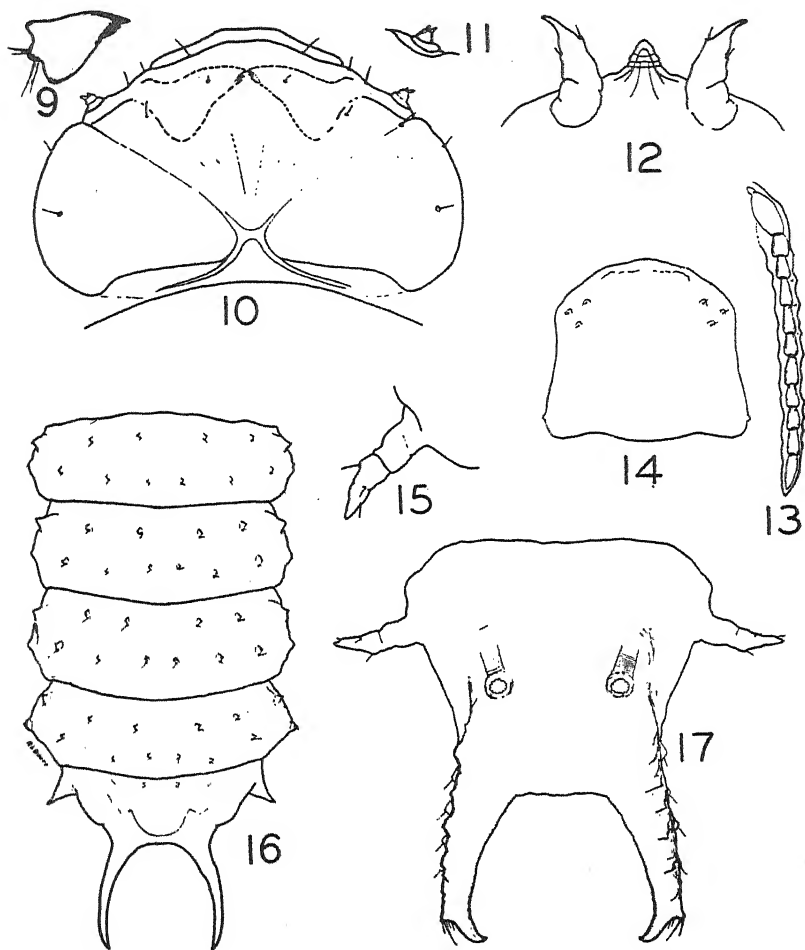
Brontispa yoshinoi Barber, dorsal views of morphological characters of mature larva and pupa. FIG. 9. Left larval mandible. FIG. 10. Larval head capsule. FIG. 11. Larval antenna. FIG. 12. Apical region of pupal pronotum. FIG. 15. Lateral abdominal process of larva. FIG. 16. Last five abdominal tergites of pupa. FIG. 17. Eighth abdominal sternite of larva (tail-shovel).

length in relation to the width. The estimated standard error of the mean of the elytral lengths was obtained from random samples of ten specimens; in the females the average elytral length was 6.39 mm.± 0.07 mm.; elytral length in the males: 5.42 mm.±0.08 mm; width of

male elytra: 1.69 mm. ±.03 mm; width of female elytra: 2.03 mm. ± .02 mm.

Egg.—Depressed, elliptical in outline, from twice as long as wide to two and one-half times as long as wide; ends broadly rounded; upper surface brown, darker at sides, slightly convex, distinctly coarsely, rather evenly reticulate, cells of reticulation either hexagonal or pentagonal, this sculpturing disappearing on ventral surface at middle, also paler and usually very feebly concave ventrally.

Length, 1.6–1.8 mm.

First instar larva.—Similar to mature larva but differing in having head comparatively larger in relation to body, clypeus more prominent; pronotum slightly wider and distinctly longer than either of remaining thoracic tergites; abdomen with lateral processes small, being inconspicuous knob-like structures and very slightly protruding from sides, these knob-like structures each bearing two or three rather long setae at apices; eighth tergite with largest lateral processes, obtuse apically, slightly constricted at base, tail-shovel not distinctly sclerotized, with spines obscure but with numerous lateral setae rather long and particularly abundant along lateral margins of prongs; prongs in outline distinctly more arcuately curved, each apex with acute, inwardly curved spine, space between prongs twice as broad as long at widest point.

Mature larva.—Body elongate, subparallel sided, very gradually narrowing cephalically, depressed; cuticle whitish to pale testaceous, with mandibles and tail-shovel darker. *Head capsule* (fig. 10) wider than long (70:42); basal margin, outlined by occipital suture, inwardly, obliquely arcuate becoming distinctly rather narrowly emarginate at middle forming short coronal suture; sides and anterior margin broadly rounded; cranial surface slightly convex, with a feeble median longitudinal impression narrowest near base of frons expanding anteriorly with widest point at anterior margin about width of clypeus, outlined at sides by apparent lines resembling sutures, but composed of minute tubercles arranged densely in lines, between lines smooth, remainder of surface rather densely tuberculate, tubercles flattened, rounded and slightly elevated (cleared specimens revealing post-frontal sutures originating from basal emargination, coronal suture, and running obliquely, cephalically to anterior margin just laterad of antennae), setae sparse, few confined to lateral and apical margins; antenna (fig. 11) three-segmented, basal segment largest, transverse, very short, second segment longer but much narrower than basal, slightly wider than long, third arising from outer side of apical flattened surface, another smaller segment arising inside and adjacent to third proper, narrowly rounded apically; ocelli arranged in transverse rows on anterior surface just laterad of antennal insertions, on each side with row of four ocelli arranged vertically with a smaller ocellus slightly posterior to ocelli row near middle; labrum barely visible from above; mandibles tridentate (fig. 9). *Thorax* with tergites distinctly broader than long, rectangular; *pronotum* slightly wider but very slightly shorter than head, anterolateral angles more acute than posterolateral angles, surface with sculpturing similar to head but intersegmental areas minutely spinulate, few hairs arising at lateral margins; *mesonotum* slightly wider but not as long as pronotum, lateral margins slightly bisinuate with shortly projecting setaceous knob-like processes at each side of transverse

median fold, surface microscopically spinulate; *metanotum* slightly wider but same length as preceding tergite, lateral margins, fold and surface similar to mesonotum; each intersegmental pleural area between pro- and mesothorax with a rather large conical laterally projecting process visible from above, opening into rounded spiracle, apically, trachea from spiracle enters mesothoracic cavity. *Abdomen* apparently eight segmented, first seven broader than long, nearly all same length but slightly increasing in width posteriorly with seventh tergite widest; eighth segment (fig. 17) (tail-shovel) longer than wide, forming terminal segment with two large posteriorly projecting prongs, antero-lateral margins angulate, sides parallel from angulation to lateral processes arising at basal-fifth, thence tapering to middle, from this narrowest width laterally diverging, forming lateral margins of prongs, elevated area and prongs somewhat sclerotized, elevated part beginning near basal-fourth, extending posteriorly at sides connecting with prongs, distance caudally from elevated base to truncate base between prongs nearly equal to length of prongs, concave surface with a large, rounded spiracle opening at each side near lateral margins of basal-fourth, distance between spiracles equal to width of truncate basal margin between prongs, feebly arcuate in outline at lateral margins, more so at inner margins, apices abruptly bent inwardly and upwardly with rather large but short spine at outer angles of inflection, extreme apices rather narrow and acute, dorsal lateral margins of elevated surfaces and prongs with seven or eight rather distinct spines without setae, ventrally the lateral margins of prongs bearing four spines equidistant from one another, each with curved seta arising at base, outer angle of prong apex with at least one seta, ventral surface of prongs each with four setae; abdominal surface microscopically spiculate, each tergite excepting eighth with transverse median fold devoid of spiculation; *lateral processes* (fig. 15) elongate, conical, projecting at right angles to lateral margin of each abdominal segment, from first and second segment arising from pleural area at middle, remaining processes arising posterior of middle excepting those on eighth, which arise anteriorly, each process two-thirds as long as length of tergite, broadest at base with sides acuminate, terminating in narrowly rounded apex, with a seta arising from feeble shelf-like process, at or near middle on dorsal surface and posterior side, another seta arising from anterior surface near apex, at times with a ventral subapical seta, surface rather densely spinulate (microscopically flattened spines); *spiracles* conspicuous, present on each segment, slightly projecting, nearly twice as wide as depth excepting on eighth, situated directly above lateral processes on first abdominal segment, anterior in position to processes on remaining segments excepting eighth, all spiracles with rounded openings, apparently lined with numerous small vertical carinae, thus margins of openings apparently serrated, eighth segment with spiracles very feebly projecting above surface, openings about 4 mm. apart.

Pupa.—With *head* similar to adult excepting for sclerotized transparent enveloping membrane, manifesting two large fleshy but rigid dorsal horn-like processes (fig. 12) projecting forward at each side of median interantennal projection, horn-like processes three times as long as wide, tapering anteriorly and curving laterally, apex acute, outside lateral margin with tooth-like projection bearing a seta just

beyond middle, another similar tooth-like process bearing a seta at external lateral margin near apex; interantennal process bearing a subapical seta at each side; antennal enveloping membrane externally dentate about basal five segments (fig. 13). *Pronotum* (fig. 14) similar in outline and punctuation to adult but with setaceous blunt tooth anterior to each posterolateral angle, another setaceous blunt tooth arising at outer anterolateral angle; surface with transverse unevenly margined carina-like ridge appearing just before anterior margin, more elevated laterally, three rather large bluntly rounded setaceous teeth arranged triangularly near outer anterolateral angles at about basal-fourth on each side, pair of tubercles in line with latter teeth but toward middle arranged transversely, rather close together, a pair of small seta arranged transversely, wide apart, slightly posterior to preceding pair of tubercles. *Elytra* and metathoracic wings naturally reduced, apical halves curving ventrally attaining apical margin first abdominal sternite. Abdomen (fig. 16) apparently eight-segmented but ninth fusing with eighth, each of first six segments bearing a pair of spiracles laterally, opening dorsally; lateral processes small, slightly produced, each bearing several hairs, not evident on first two segments, eighth segment with lateral processes, large, elongate, accuminate, acute apically, without setae; tergites with surface microscopically spinulate, but also bearing larger spines in more or less definite patterns, absent on first, second to seventh each with two groups of four spines arranged transversely, one row near cephalic margin, another slightly post-median, cephalic row of spinules larger more widely spread than in post-median row, dorsal-lateral area of each tergite with a single spinule directly in line with lateral process, elevated lateral fold occurring slightly anterior to each spiracle on segments three to seven with distinct spine, all conspicuous larger spines with a short seta arising near base; tail-shovel differing from mature larvae in having prongs more slender, elongate, slightly arcuate, spiracles absent, slightly broader than long, length measured from base of eighth segment to apices of prongs, width between apices of lateral processes, prongs about as long as greatest width between them; sternites four to seven each with transverse row of six to seven spinules just before middle, group of three or four spinules laterally near posterior margin, each spinule with seta arising posteriorly near base. In the pupae studied, the tail shovels of the last larval instar exuvia remained attached to the pupal tail prongs.

This species was confused with *B. chalybeipennis* Zacher by Chujo, for he interpreted specimens from Koror Island of the Palau group as being Zacher's species which was originally described from Ponape Island. Chujo proposed the new genus *Planispa* in 1937 and designated his new species, *P. castaneipennis*, as the genotype. This later proved to be a synonym of *Brontispa mariana* Spaeth, a species described almost simultaneously but having date priority. The other species which Chujo included in *Planispa* was a species he thought to be *B. chalybeipennis*.

Specimens from Koror and Babelthuap Islands agreed entirely with Chujo's redescription of *B. chalybeipennis*, but when compared with the true *B. chalybeipennis*, the Palauan species was quite distinct. *B. yoshinoi* differs from Zacher's *B. chalybeipennis* by having the

interocular structure distinctly broader than long instead of longer than broad, by possessing a narrower interantennal process which is without the thinly produced anterior margins, and by having dark metallic blue elytra as compared to the bluish green elytra of *B. chalybeipennis*. Evidently in Zacher's species sexual dimorphism of the interantennal process does not occur. The pupa of *B. yoshinoi* is easily recognized from that of *chalybeipennis* by the structure of the interantennal process, which is a simple accuminate process in *B. yoshinoi* and bifurcate in *B. chalybeipennis*.

Actually *B. yoshinoi* is probably most closely related to *B. mariana* Spaeth, for they are quite similar in general facies manifesting common characters such as sexual dimorphism of same structures and a broader than long interocular area, but they are easily differentiated as follows: *B. mariana* with brownish elytra, apical area of elytral interstices between the rows of punctures barely raised into costae, mandibles with incisor lobes elongate, overlapping nearly their entire lengths (fig. 6), interantennal projection of *mariana* ♂ broader, longer, exceeding first antennal segment, in ♀ this projection with truncate apex. The mature larva of *B. yoshinoi* has the abdominal lateral processes bearing setae at middle and on the anterior half while *mariana* has at least one seta arising at or near basal fourth of lateral process, and the prongs of the tail-shovel are more strongly dentate dorsally. The pupa of *B. yoshinoi* has the pronotum with three setaceous tubercles on each side of disc near outer anterolateral angles while in *mariana* there are four on each side of disc.

In Maulik's table (1938) *B. yoshinoi* keys out to *B. surigaoana* Uhmann, but the latter species differs in being smaller, in having the interantennal process broader and more truncate apically, in lacking a scutellar row of punctate striations in each elytron, and in coloration.

Since 1938 only a single new species has been described in *Brontispa*, and this species from Namorik atoll in the Marshall Islands was named *B. namorikia* by Maulik (1946). This species superficially resembles and may be confused with *B. yoshinoi*. However, the elytra in *B. namorikia* have a greenish tint, the interantennal projection is very broad and apically truncate, the interocular process is oblong, being nearly as wide as long, and the pupa has the interantennal process bifurcate as in *B. chalybeipennis*.

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ON THE RELATIONSHIPS OF SOME MAMMAL FLEAS TO THEIR HOSTS

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INTRODUCTION

Knowledge of the biology of fleas in their native environments consists chiefly of records of their geographical and host distribution. Information about their life histories and host relationships is limited very largely to that acquired in epidemiological investigations of plague and of other flea-borne diseases. Such work has usually been governed by hygienic and economic necessity and unfortunately has not always been endowed with a broad ecological point of view. Considerable attention has been given to the development of a "satisfactory" flea index, that is, an estimate of the density of flea populations as indicated by samples taken from the hosts, whereas little has yet been done to elucidate the *factors* which determine the density of the population-at-large, of which the individuals collected on hosts may be a small and varying fraction. The paucity of material on the ecology of fleas has prompted us to prepare these somewhat fragmentary notes.

During a survey of small mammals carried out in the years 1936–39 in Bagley Wood near Oxford, England, an opportunity arose to observe the relationships of several flea species to their hosts. This paper is based on observations made at monthly intervals from May 1938 through April 1939, with the exception of July and August. The material is too limited for any very definite conclusions to be made; nevertheless the study presents several points of interest. It was made on a population of live mammals marked for identification and released after each capture; thus the host population was not destroyed and interference with its normal activity was thereby considerably reduced. Changes in the number of hosts and in the number of fleas taken from the hosts were observed simultaneously, so that, if desirable, the two sets of data might be combined to give a more accurate picture of flea infestation and seasonal activity. Records were kept of the flea populations of each individual host at each capture, and of the rapidity with which hosts pick up fleas. Finally, this study was carried out in the same wood in which, ten years earlier, a somewhat similar investigation of parasites of small mammals had been made (Elton *et al.*, 1931); the comparison of results has proved interesting throughout.

The field work was done primarily by one of us (F. C. E.) while a research student at the Bureau of Animal Population, Oxford University, and the identification and study of the flea material by the other

(R. B. F.) while a research student in the Hope Department of Entomology, Oxford University. The determination of flea species was carried out with the aid of Rothschild's synopsis (1915); the nomenclature is that of da Costa Lima & Hathaway (1946), except that *Megabothris* and *Malaraeus* of Jordan (1933) are retained in preference to *Trichopsylla*. We should like to thank the President and Fellows of St. John Baptist College, Oxford, for permission to work in Bagley Wood; Mr. Charles Elton and the Bureau of Animal Population, under whose helpful guidance the field studies were made; Professor P. A. Buxton, Dr. B. M. Hobby and Mr. W. L. Jellison for valuable suggestions in preparing these notes; and Dr. C. B. Allendoerfer and Dr. C. W. Cotterman for advice on statistical procedures.

PLACE AND METHODS OF STUDY

Bagley Wood lies about four miles from Oxford in a south-westerly direction and is in the county of Berkshire. A more detailed description of the study areas and of the techniques used in trapping and marking the mammals has been published elsewhere (Evans, 1942), but a brief account is desirable here. The area in which these observations were made was one of mixed woodland types, including plantations of larch (*Larix decidua* and *L. kaempferi*), spruce (*Picea sitchensis*) and cedar (*Thuja plicata*), as well as a mixture of these with such broad-leaved species as oak (*Quercus robur* and *Q. petraea*), ash (*Fraxinus excelsior*) and sycamore (*Acer pseudoplatanus*). The soil was partly gravel and partly clay overlay, and was high enough above the level of the Thames valley and tributary streams not to be flooded at any time of year. All of the study area was well within the wood boundaries, and the nearest human habitations were about half a mile away, so that there was little chance of flea transfer from other areas.

With a grid system of fixed trapping positions which covered two neighboring areas of 6.2 and 4.0 acres, a uniform and strictly comparable sample of the small mammal population was obtained for each month. Animals were trapped alive in Tring traps, baited with cocoanut and provided with nest boxes, and were banded with numbered rings before being released (Chitty, 1937). The weight, sex, approximate age and sexual condition were recorded for each capture. Trapping was continued on each area for four successive nights in each month, the areas being trapped in succession and not simultaneously. The same individuals were often recaptured on two or more trapping nights in each month, and many were caught from month to month. The traps were reset, after removal to another fixed point in the area, immediately after they had been examined and were thus open for 24-hour periods; however, most of the mammals taken were strongly nocturnal in their habits, and it is probable that the great majority of them were not in the traps for more than 12 hours, often for less. Very few rodents died in the traps, but shrews were apparently unable to survive these trap conditions, for they were almost always found dead. Records of fleas from dead specimens were not included in the calculations of flea-indices.

Fleas were removed at each capture. Removal was easily effected by blowing against the fur of the animal, which was held over a white cloth; the fleas collected on the cloth and were transferred to glass tubes.

Each host was examined carefully until it was reasonably certain that all fleas had been removed. A negligible number of fleas escaped by jumping off the cloth. During the warm summer months it was found that fleas sometimes left the host for the nesting material provided in the traps for the mice; this material was carefully searched each time the trap was sprung, and any fleas found in it were attributed to the captured host.

RESULTS

Species composition of the host fauna. The small mammals trapped included three species of rodents and three of insectivores, whose names and zoological affinities are as follows:

ORDER RODENTIA
    Family Muridae
        Subfamily Murinae
            Apodemus sylvaticus sylvaticus (L.), Long-tailed Wood Mouse
    Family Cricetidae
        Subfamily Microtinae
            Clethrionomys glareolus brittanicus (Miller), Bank Vole
            Microtus agrestis hirtus (Bellamy), Field Vole

ORDER INSECTIVORA
    Family Soricidae
        Subfamily Soricinae
            Sorex araneus castaneus Jenyns, Common Shrew
            Sorex minutus minutus L., Pigmy Shrew
            Neomys fodiens bicolor (Shaw), Water Shrew

This assemblage included most if not all of the small mammal species characteristic of the woodland floor habitat of Bagley Wood. However, the field vole was comparatively scarce, and trapping techniques were not designed to insure an adequate representation of shrews. Only the wood mouse and bank vole were caught frequently enough to provide flea data of any quantity.

Species composition of the flea fauna. During the period of this survey a total of 1213 fleas were collected, distributed according to species as follows: *Ctenophthalmus agyrtes nobilis* (Roths.), 1016; *Malaraeus penicilliger* (Grube), 101; *Megabothris turbidus* (Roths.), 38; *Hystrichopsylla talpae* (Curtis), 38; *Palaeopsylla soricis* (Dale), 9; *Rectofrontia pentacanthus* (Roths.), 4; *Megabothris walkeri* (Roths.), 3; *Doratopsylla dasycnemus* (Roths.), 3; *Nosopsyllus fasciatus* (Bosc d'Antic), 1. All nine species of flea are common in this region and had been previously recorded from Bagley Wood (Elton *et al.*, 1931). This earlier survey obtained three additional species which might have been expected to occur in the present sample but which were not found: *Palaeopsylla minor* (Dale) and *Ctenophthalmus bisoctodentatus* (Kolen.) whose typical host is the mole (*Talpa europaea* L.), and *Leptopsylla silvatica spectabilis* (Roths.), whose typical host is the field vole. A fourth species, *Typhloceras poppei* (Wagn.), has been recorded from the wood mouse in the nearby Tubney Wood (Freeman, 1939).

Of the 650 fleas taken from *Apodemus* and the 556 from *Clethrionomys*, 605 and 411 respectively belonged to one species, *C. agyrtes*. The flea faunas of these two hosts were thus largely composed of a single species. This phenomenon is probably of rather wide occurrence and has been observed in work on many flea populations.

Specificity of host selection. Many species of flea have one particular host species in relation to which their density of population may reach a maximum. Some are more specific than others in their choice of host, though the reason for this may lie as much in the lack of opportunity for host transfer as in any physiological restriction. On the other hand, frequent opportunity for transfer may result in accidental parasitism, such as the occurrence of rodent fleas on predatory birds and mammals, and may falsely suggest a corresponding lack of host specificity. Many small mammal species in a given community appear to utilize the same burrow and runway systems and to compete or co-operate with one another in various ways; this closeness of association may partially account for the lesser degree of host specificity shown by fleas of these animals in comparison with those of larger mammals. During the present study, a large number of burrow entrances were found to be used by both *Apodemus* and *Clethrionomys*, providing abundant opportunity for exchange of fleas. Nevertheless the flea fauna showed considerable range in specificity of host selection.

The different species of fleas were divided into three general groups: (A) those which were constantly present on both the murine *Apodemus* and the microtine *Clethrionomys*, (B) those which are apparently more characteristic of microtine rodents and which occurred on *Clethrionomys*, but either sporadically or not at all on *Apodemus*, and (C) those which were present only sporadically on either *Apodemus* or *Clethrionomys*, and which seem to be primarily parasites of other hosts.

The only species which occurred regularly on both *Apodemus* and *Clethrionomys* and which therefore fell into group A was *C. agyrtes*. This is recognized as by far the most abundant flea on small British rodents, and in this population sample it comprised 83 per cent of the total flea fauna. It was the only species taken in large numbers on *Apodemus*. It is evidently capable of maintaining breeding colonies on *Apodemus*, *Clethrionomys* and *Microtus;* it is also known from many other rodents and insectivores, though it has not been found to form a high percentage of their flea populations (Elton *et al.*, 1931; Freeman, 1939; Matheson, 1934; Thompson, 1938), and for these hosts it may belong to the group C category.

Three species which occurred on *Clethrionomys* and rarely or not at all on *Apodemus* were assigned to group B. Of the 101 specimens of *M. penicilliger* collected, 91 were taken from *Clethrionomys*, on which host it was second only to *C. agyrtes* in abundance. Likewise 29 of the 39 *M. turbidus* and all three specimens of *M. walkeri* came from this host. The latter flea is typically a parasite of *Microtus;* Elton *et al.* (1931) found that 17 per cent of *Microtus* carried *M. walkeri* and only two percent carried *M. turbidus* and *M. penicilliger*, while 17 percent of *Clethrionomys* carried *M. penicilliger*, 12 percent carried *M. turbidus* and three percent carried *M. walkeri*. The two species of one genus, *M. turbidus* and *M. walkeri*, thus appear to occur in different but sympatric habitats, one of which is also occupied by a member of a very closely allied genus, *M. penicilliger*. *Apodemus* had no characteristic species; it is probable that *T. poppei* has this status when it is present in the population (Freeman, 1943).

The remaining five species were taken only occasionally on *Apodemus* and *Clethrionomys* and formed group C. The large *H.*

talpae is by name associated with the mole and is indeed most frequently found on this animal, though it is never numerous on any host; but it can almost certainly maintain itself apart in the nests of small rodents and shrews. It was taken in small numbers from *Apodemus*, *Clethrionomys* and *Microtus*. Large flea larvae, apparently of this species, have been observed in the nests of *Microtus* and adults in copulation have been taken on the fur of *Apodemus* (Elton *et al.*, 1931). O'Mahoney (1939) records this species from Ireland, where the mole is absent. *R. pentacanthus* is found on several species of small rodents and insectivores, but has generally been taken in very small numbers. Freeman (1942) has suggested that species of this genus spend little time on the host and that such records may give little idea of their real numbers. *N. fasciatus* is a cosmopolitan species on commensal rats and the house mouse; a small colony of the brown rat, *Rattus norvegicus* (Erxleben), was present around the cottages at the edge of Bagley Wood, about half a mile from the study area, and the single specimen recorded here was probably a straggler. Both *P. sorecis* and *D. dasycnemus* are typically shrew fleas.

Seasonal distribution of flea species on their hosts. Table I presents the composition of the monthly flea collections from *Apodemus* and *Clethrionomys*. These figures do not indicate population trends, as the number of host records differs for each month, but they do suggest certain seasonal differences in the relationships of the various flea species to these hosts. The group A species, *C. agyrtes*, was at all times the predominating flea on both *Apodemus* and *Clethrionomys*. Group B species were also taken regularly on *Clethrionomys*, but there was a tendency for them to occur on their less frequent host, *Apodemus*, chiefly in the autumn and winter months, when *C. agyrtes* was least abundant. This tendency was even more apparent in group C, whose members were found only in small numbers on either host; of the 48 individuals belonging to the five species of this group, 38 were taken from October through January.

Seasonal differences in flea distribution may be due to a variety of factors. Flea species vary in the amount of time spent on the host; some spend all or most of their adult life there, while others may be chiefly nest or burrow inhabitants. They may also exhibit varying degrees of habitat preference. Jameson (1947) found that some species of fleas from small mammals in Kansas occurred on the host when the latter lived in a given habitat but were absent when the host lived in a habitat of different type. Microclimatic conditions will need to be carefully studied before this problem of distribution can be understood.

Association of flea species on individual hosts. Among the 730 captures of *Apodemus* and the 325 captures of *Clethrionomys* recorded in this study, there were 275 and 178 infestations of fleas, respectively. In 84 of these infestations there were two or more species of flea present; the largest number of species on a single host was four. It is of interest to determine what degree, if any, of interspecific association existed among the various flea species. The test of this association proposed by Cole (1949) requires larger samples than we can provide except in the case of *C. agyrtes* and *M. penicilliger*. On *Apodemus*, these two species occurred jointly 4 times, *C. agyrtes* was present when *M. peni-*

cilliger was absent on 254 occasions, *M. penicilliger* was present when *C. agyrtes* was absent 51 times, and neither species was present on 421 occasions. On *Clethrionomys*, the two species occurred jointly 47 times, *C. agyrtes* was present when *M. penicilliger* was absent 108 times, *M. penicilliger* was present when *C. agyrtes* was absent 15 times, and neither species was present on 155 occasions. The coefficient of interspecific association was found to be $-0.808 \pm .175$ on *Apodemus* and $+0.537 \pm .109$ on *Clethrionomys*. This indicates a strong negative association of *C. agyrtes* and *M. penicilliger* on *Apodemus* and what may

TABLE I

COMPOSITION OF THE MONTHLY FLEA COLLECTIONS FROM APODEMUS
AND CLETHRIONOMYS

	GROUP A	GROUP B		GROUP C					
	C. agyrtes	*M. penicilliger*	*M. turbidus*	*M. walkeri*	*H. talpae*	*P. soreccis*	*D. dasycnemus*	*R. pentacanthus*	*N. fasciatus*
From *Apodemus:*									
January.........	59	2	0	0	5	0	0	0	0
February........	54	0	0	0	2	0	0	1	0
March..........	68	0	0	0	1	0	0	0	0
April...........	84	0	0	0	0	0	0	0	0
May............	67	0	0	0	2	0	0	0	0
June...........	93	1	2	0	0	0	0	0	0
September.......	88	3	3	0	2	1	0	0	0
October.........	37	4	2	0	4	3	1	0	0
November.......	28	0	2	0	0	1	0	1	0
December.......	27	0	0	0	1	0	0	1	0
From *Clethrionomys:*									
January.........	51	13	5	0	4	0	0	0	0
February........	27	2	1	0	0	0	0	0	0
March..........	25	5	0	0	0	0	0	0	0
April...........	27	3	1	0	0	0	0	0	0
May............	72	7	3	1	0	0	0	0	0
June...........	99	10	5	1	0	0	0	0	0
September.......	23	4	3	0	1	0	0	0	0
October.........	31	15	7	1	10	1	0	0	0
November.......	25	9	2	0	2	0	0	0	1
December.......	31	23	2	0	2	0	0	1	0

perhaps be characterized as a moderate positive association on *Clethrionomys*. The interacting behavior of these two species of flea is apparently quite different on *Apodemus* from that on *Clethrionomys*. Perhaps the fur of *Clethrionomys*, which is somewhat longer and coarser than that of *Apodemus*, may allow *C. agyrtes* and *M. penicilliger* to exist side by side on that host and to avoid such direct competition as may occur on *Apodemus*.

The sex ratio in fleas. It has frequently been observed that more female than male fleas are found in samples collected from rodent

TABLE II

Distribution of Captures of Apodemus and Clethrionomys Showing the Number of C. agyrtes at Capture

	Number of *C. agyrtes* at Capture																					Total Captures	Total Fleas	Mean No. per Capture
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
Apodemus																								
Initial Captures.....	82	24	7	0	3	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	118	63	0.534
Subsequent Captures.....	383	114	40	34	16	9	8	1	0	1	2	3	0	0	0	0	0	0	0	0	1	612	542	0.886
Captures after 24 hours.....	199	69	22	19	10	7	4	1	0	1	1	2	0	0	0	0	0	0	0	0	0	335	317	0.956
Captures after one month.....	124	32	12	13	1	1	3	0	0	0	1	0	0	0	0	0	0	0	0	0	1	188	152	0.808
Total Captures.....	465	138	47	34	19	10	8	1	1	1	2	3	0	0	0	0	0	0	0	0	1	730	605	0.829
Clethrionomys																								
Initial Captures.....	57	13	11	9	0	2	2	1	0	1	0	2	0	1	1	0	0	0	0	0	0	99	135	1.364
Subsequent Captures.....	120	56	15	6	11	5	5	4	1	1	0	1	0	0	0	0	0	1	0	0	0	226	276	1.221
Captures after 24 hours.....	25	15	7	3	2	1	0	1	0	1	0	1	0	0	0	0	0	1	0	0	0	57	95	1.667
Captures after one month.....	71	25	8	3	6	1	3	1	1	0	0	1	0	0	0	0	0	0	0	0	0	120	117	0.975
Total Captures.....	177	69	26	15	11	7	7	5	1	2	0	3	0	1	0	0	0	1	0	0	0	325	411	1.265

hosts, and in the present study similar findings were noted for the two flea species which were taken in fairly large numbers. The sample of 1016 *C. agyrtes* showed a ratio of 67.9 males per 100 females and that of 101 *M. penicilliger* a ratio of 36.5 males per 100 females. This may of course reflect either a similar inequality in the larger populations of these species, or a difference in the activity and behavior of the sexes, or both. For some species of fleas it is known that the adult life of females is significantly longer than that of males; hence, if the ratio at emergence is not already biased in favor of males, females will tend to predominate. It has also been pointed out that females tend to emerge sooner than males, and if samples are taken early in the development of a colony then females will predominate (Hirst, 1924). Although copulation may take place, in some species at least, between unfed individuals, females do not lay eggs unless they have fed, nor continue to lay unless they continue to feed; the necessity for more frequent feeding may in itself account for the presence of more females than males on the host. Experimental evidence of sex differences in habits has been obtained by placing equal numbers of the two sexes in a nest box occupied by a mouse and finding that significantly more females than males appeared on the host (Buxton, 1938).

Extent of breeding. In the present study, all *C. agyrtes* females were examined for eggs, which can be clearly seen, in the later stages of development at least, in xylol-cleared specimens. Gravid females were found in all months in which collections were made, indicating that there was no cessation of breeding. The percentage of females that were gravid ranged from a low of 20.5 in December to a high of 51.0 in February; there was·no clear indication of seasonal variation.

Presence of mites on fleas. Fifty-seven mites, all larval phases of some species of Tyroglyphinae, were found on the fleas. Dr. F. W. Turk, who has very kindly examined some of this material, has identified the specimens as *Tyroglyphus farinae* (L.). These mites were taken from *C. agyrtes, M. penicilliger* and *M. turbidus;* their presence is a case of phoresy, not of feeding on the fleas.

Rate of re-infestation of hosts. It has been shown that rodents from which the flea population has been removed may regain many fleas within a very short time (Meyer, 1938). Quite independently, the present study made a similar observation for *Apodemus* and *Clethrionomys* and gave further indication of the rate at which re-infestation occurs. The only figures suitable for statistical analysis were those for *C. agyrtes*. The following series of typical records gives the number of *C. agyrtes* taken from individual hosts on four successive trapping days:

	Apodemus					*Clethrionomys*		
0,	1,	0,	4		0,	0,	0,	2
0,	2,	0,	3		1,	1,	1,	2
2,	3,	0,	2		6,	1,	2,	2
0,	3,	0,	3		0,	2,	3,	0
1,	2,	4,	1		3,	0,	1,	0
1,	0,	9,	1		4,	2,	2,	1
0,	0,	0,	5		3,	3,	2,	1
3,	11,	2,	—		—,	2,	9,	7
0,	0,	6,	5		1,	—,	5,	17
1,	5,	1,	7		0,	5,	1,	11

(— indicates that the host was not captured on that day.)

It is clear that within 24 hours or less hosts may acquire as many or more fleas than they were carrying the previous day. In many cases, fleas were recovered from hosts that had had none the day before, and in one instance 17 fleas were recovered from a bank vole after its previous flea fauna of 5 individuals had been removed the preceding day.

To analyze the rate of re-infestation, the numbers of fleas found on hosts whose recapture occurred approximately 24 hours after previous capture were compared with those found on hosts recaptured after one month had elapsed since previous capture. The distributions of these records showing the number of *C. agyrtes* at capture is given in Table II (Subsequent captures: captures after 24 hours vs. captures after one month). The marked skewness of the data requires their transformation into normal distributions for statistical treatment. It was suggested to us by Dr. C. B. Allendoerfer that this might be accomplished

TABLE III

NUMBERS OF INFESTATIONS AND NUMBERS OF C. AGYRTES TAKEN EACH DAY FROM
APODEMUS WHICH WERE CAUGHT ON THREE AND FOUR SUCCESSIVE
TRAPPING DAYS

	SUCCESSIVE DAYS OF CAPTURE			
	First	Second	Third	Fourth
FOUR-DAY RECORDS				
Number of captures.................	33	33	33	33
Number of infestations.............	13	16	12	23
Per cent infested...................	39.4	48.5	36.3	69.7
Total number of fleas..............	19	32	29	47
Fleas per infestation...............	1.46	2.00	2.42	2.04
THREE-DAY RECORDS				
Number of captures.................	32	32	32	
Number of infestations.............	17	20	19	
Per cent infested...................	53.1	62.5	59.4	
Total number of fleas..............	59	53	51	
Fleas per infestation...............	3.47	2.65	2.68	

by substituting a new variable, $Y = \log 1 + X$, for the original variable X = number of fleas at capture. The transformed data were then plotted on logarithmic probability paper, with $1 + X$ plotted on the logarithmic scale and on the other the cumulative percent of the number of fleas less than X. The results were fairly good approximations to straight lines, indicating that the new distributions were normal. In each such comparison the two lines had nearly the same slope, suggesting equal variances in the two series. Using the transformed variable Y, the significance of the difference between the means for the two series was tested by the usual Student-Fisher t formula. For the data on *Apodemus*, we find $t = 1.38$ (degrees of freedom $= n_1 + n_2 - 2 = 521$), and for the data on *Clethrionomys* $t = 1.92$ (d.f. $= 175$). Neither of these values of t denotes significance at the 5 percent level. Thus there was

no proved significant difference between the numbers of fleas on hosts recaptured 24 hours after previous capture and the numbers present on hosts with an interval of 30 days between captures. The hypothesis that these hosts regained as many fleas within 24 hours as they were found to have after a much longer interval of time need not therefore be abandoned.

The removal of fleas at daily intervals over a four-day trapping period did not apparently result in any decrease in flea abundance. *Clethrionomys* were rarely caught more than two days in succession, but for *Apodemus* there were 32 records of captures on three successive

TABLE IV

MONTHLY DISTRIBUTION OF CTENOPHTHALMUS AGYRTES ON
APODEMUS SYLVATICUS

	Number of hosts	Number of infested hosts	Percent of hosts infested	Number of captures	Number of infested captures	Percent of captures infested	Number of fleas	Mean number of fleas per host	Mean number of fleas per capture	Mean number of fleas per infested host	Mean number of fleas per infested capture
January.........	37	15	40.6	85	21	24.7	59	1.59	0.69	3.94	2.81
February.........	36	25	69.5	87	35	40.2	54	1.50	0.62	2.16	1.54
March...........	27	21	77.6	89	31	34.8	68	2.52	0.76	3.24	2.19
April............	27	17	63.0	73	33	45.3	84	3.11	1.15	4.95	2.55
May.............	17	15	88.3	32	25	78.2	67	3.94	2.10	4.46	3.74
June.............	17	17	100.0	42	27	64.4	93	5.47	2.22	5.47	3.44
September.......	28	20	71.5	43	33	76.6	88	3.14	2.04	4.39	2.66
October..........	35	20	57.3	79	25	31.6	37	1.12	0.47	1.85	1.48
November.......	48	15	31.2	95	20	21.0	28	0.58	0.29	1.87	1.40
December........	45	14	31.2	104	15	14.7	27	0.60	0.26	1.93	1.80
ENTIRE PERIOD OF STUDY											
♂♂ hosts......	56	42	75.0	319	140	43.8	328	5.85	1.03	7.80	2.34
♀♀ hosts......	62	42	62.7	411	125	30.4	277	4.46	0.67	6.60	2.22
Totals.......	118	84	71.2	730	265	36.3	605	5.14	0.83	7.21	2.28

days and 33 additional records of captures on four successive days. The number of infestations and the numbers of *C. agyrtes* taken each day for these records are shown in Table III. No marked decline is evident. If captures had been repeated over longer periods or at shorter intervals the number of infestations and the number of fleas per capture might well have decreased.

These facts suggest that individual fleas did not spend any prolonged period on their hosts. Freeman (1945) has shown that *N. fasciatus* left their hosts in considerable numbers every day, at a feeding place which their hosts were visiting regularly. It is likely that nests and burrows of the hosts are the principal foci of these flea populations.

No data are available from nests of *Apodemus* or *Clethrionomys*, but an analysis of the fauna of 38 *Microtus* nests gave counts of as many as 92 fleas per nest (Davis, 1934). In our study, the greatest number of *C. agyrtes* taken in a single infestation was 20 (Table II). As a rule, however, the number was very much lower and about 50 percent of the infestations were made up of single specimens. Clearly the maximum or potential "flea-holding" capacity of the host was rarely if ever attained. It was also evident that *C. agyrtes* was not distributed at random among the captures of either *Apodemus* or *Clethrionomys*. This was tested by fitting a Poisson series to the data in Table II for the total captures of

TABLE V

MONTHLY DISTRIBUTION OF CTENOPHTHALMUS AGYRTES ON
CLETHRIONOMYS GLAREOLUS

	Number of hosts	Number of infested hosts	Percent of hosts infested	Number of captures	Number of infested captures	Percent of captures infested	Number of fleas	Mean number of fleas per host	Mean number of fleas per capture	Mean number of fleas per infested host	Mean number of fleas per infested capture
January.........	21	17	81.0	47	25	53.3	51	2.43	1.09	3.00	2.04
February........	15	9	60.0	23	9	39.2	27	1.80	1.17	3.00	3.00
March..........	9	5	55.6	15	8	53.4	25	2.78	1.66	5.00	3.12
April..........	8	7	87.5	11	8	72.8	27	3.38	2.46	3.85	3.34
May............	14	8	57.2	22	13	59.0	72	5.15	3.28	9.00	3.27
June...........	17	15	88.3	28	24	85.5	99	5.73	3.42	6.60	4.12
September.......	29	10	34.6	37	10	27.0	23	0.79	0.62	2.30	2.30
October.........	46	17	37.0	59	17	28.8	31	0.67	0.53	1.82	1.82
November.......	34	13	38.2	40	13	32.5	25	0.74	0.62	1.92	1.92
December........	31	15	48.5	43	21	48.9	31	1.00	0.72	2.07	1.48
ENTIRE PERIOD OF STUDY											
♂♂ hosts......	58	44	75.9	199	97	48.8	302	5.21	1.52	6.88	3.12
♀♀ hosts......	41	29	70.8	126	51	40.5	109	2.66	0.87	3.76	2.14
Totals.......	99	73	73.8	325	148	45.6	411	4.15	1.26	5.63	2.78

each host (Snedecor, 1946, p. 441); the deviation from the Poisson series tested by chi-square indicated that, when captured, some individual hosts were more heavily infested than others. Variations in the number of fleas available for infestation, due to differences in the flea populations of the various burrows at various times of year, seem to afford a more plausible reason for this non-random distribution than differences in susceptibility or in activity of the hosts.

Flea indices. *C. agyrtes* was the only species of flea which we took in sufficient numbers for the calculation of indices of relative abundance. Tables IV and V present the data for this flea on *Apodemus* and *Clethrionomys* respectively.

In the ordinary type of flea survey employed by epidemiologists and others, indices are usually based on collections from hosts which are caught once only and which are thereby removed forever from the host population, thus possibly affecting future host-parasite relationships. The technique used in the present study avoided this possibility and provided a series of collections from hosts which were caught and recaught varying numbers of times. In the latter technique, initial captures would correspond to those obtained by ordinary survey methods. By grouping our data according to initial and subsequent captures, it is possible to compare the two methods of collection. The distribution of records showing the number of *C. agyrtes* at capture is presented in Table II (Initial captures vs. Subsequent captures). For each host, the data were transformed as described above and were then subjected to the Student-Fisher t test. For the data on *Apodemus*, we find $t = 2.11$ (d.f. $= 728$), and for the data on *Clethrionomys* $t = 0.154$ (d.f. $= 323$). The t value for *Clethrionomys* indicates no proved statistical difference between the two series; that for *Apodemus* indicates a significant difference at the 5 percent level but not at the 1 percent level. The data are not very extensive but, if they are accepted as adequate samples, the comparisons do not reveal any striking differences between the results of the two methods of collection. It is evident, however, that they do not always give similar results.

For each species of host, the monthly indices point clearly to a rise, not only in the number of fleas per host, but also in the numbers of hosts infested, during the spring, with a maximum reached in the summer and a subsequent decline to a winter low. Such seasonal variation has been observed repeatedly, yet it is by no means clear how much this is due to a real decline in the numbers of fleas present in the breeding environment (the nests and burrows of the hosts), how much to a decrease in flea activity, or how much to changes in the numbers or activity of the host population. The presence of certain flea species on occasional hosts primarily in the autumn and winter months, which was observed in this study, suggests seasonal differences in habits, perhaps of host as well as of parasite. Changing conditions of temperature and humidity probably also bring about differences in activity, but again we lack definite information. The absence of specific knowledge about such points as these re-emphasizes the need for further intensive study of flea ecology.

SUMMARY

1. During a survey of small mammals near Oxford, England, fleas were collected regularly each month from May, 1938, through April, 1939, except for July and August. The hosts were taken alive and released for subsequent recapture; all fleas were removed at each capture.

2. Nine species of fleas were recorded, taken almost wholly from the wood mouse, *Apodemus sylvaticus*, and the bank vole, *Clethrionomys glareolus*. A single species, *Ctenophthalmus agyrtes*, accounted for 1016 of the 1213 individual fleas collected.

3. The various flea species were arranged in three groups: (A) those which were constantly present on both *Apodemus* and *Clethri-*

onomys, (B) those which occurred on *Clethrionomys*, but rarely or not at all on *Apodemus*, and (C) those which were present only sporadically on either *Apodemus* or *Clethrionomys* and which were apparently primarily parasites of other host species.

4. When fleas of group C did occur on *Apodemus* and *Clethrionomys*, it was principally in the autumn and winter months, when *C. agyrtes* was least abundant.

5. As many as four species of flea were obtained on an individual host. *C. agyrtes* and *M. penicilliger* showed a strong negative association on *Apodemus* and a moderate positive association on *Clethrionomys*. It is suggested that fur differences between the two host species might account for this difference in association.

6. The sample of 1016 *C. agyrtes* showed a sex ratio of 67.9 males per 100 females, and that of 101 *Malaraeus penicilliger* a ratio of 36.5 males per 100 females.

7. Gravid females of *C. agyrtes* were found in all months in which collections were made; the percentage of females that were gravid ranged from a low of 20.5 in December to a high of 51.0 in February.

8. Mites of the species *Tyroglyphus farinae* were found as "riders" on *C. agyrtes*, *M. penicilliger* and *Megabothris turbidus*.

9. Individual hosts from which the flea population had been removed were found frequently to acquire in 24 hours or less as many or more fleas than they were carrying the previous day. It is likely that the principal focus of the flea populations lay in the nests and burrows of the hosts rather than on the hosts themselves.

10. The method of collecting fleas described herein was shown to provide indices not strikingly different from those obtained by ordinary survey techniques. Indices of relative abundance derived for *C. agyrtes* showed a definite rise in the spring and a decline in the autumn and winter months.

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KURS OBSHCHEI ENTOMOLOGII, by B. N. Shvanvich. Sovietskaia Nauka. 900 pages, 590 text figures. Price, 30 rubles.

This work marks the appearance of a text in the Russian language which may be considered comparable to the well-known works of Comstock, Imms, and Henneguy, though differing from them somewhat in scope. It is hardly as ambitious a publication as Berlese's *Gli insetti* or Schröder's *Handbuch der Entomologie*.

Shvanvich's text, in general, makes a favorable impression. The stress is on insect morphology, in which field the author draws heavily from Snodgrass; he also places considerable emphasis on physiology, and the physiological and morphological parts seem to be well integrated, both phases in many instances being considered together. Indeed, the work is so predominantly morphological and physiological that other phases of entomology receive comparatively little attention. An interesting feature is the discussion of coloration and the evolution of color patterns, based to a considerable extent upon the author's original investigations, and to which 52 pages of the text are devoted. This discussion leads logically to a consideration of protective resemblance and mimicry. Embryology, insect life histories, and metamorphosis are given due consideration, but to find any material dealing with ecology, human relationships of insects, or most phases of insect biology, one must, except for the brief foreword, look in scattered places throughout the text. The treatment of taxonomy is brief but concentrated. The one-sided emphasis hardly fits the title, which may be translated, "A course in general entomology".

It is difficult to determine how much original work has gone into the text. An extensive list of citations (26 pages) is appended, and American and Western European authors are given their just representation. Here again, taxonomic works, including some important ones from the Russian literature, are neglected. However, documentation is sparingly used. Credit is given for many of the figures and some are marked "Orig." (original), but many, among which one may recognize familiar illustrations, are used without credit. In the foreword the author does state, however, that such illustrations are taken from either Snodgrass or Weber.

The printing and reproduction of illustrations is good; the paper and binding only fair, though better than that used in many recent Russian publications. We secured a copy from an American dealer for about $5.00.—M. T. J.

OLFACTOMETER EXPERIMENTS WITH
MALE BRACONIDS

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The parasitic wasp, *Microbracon hebetor* (Say) is well known in biological control as a very useful enemy of lepidopterous pests in stored grains. The wasp is also well known for its usefulness in genetic investigation as evidenced by the fact that Dr. P. W. Whiting and associates have published genetic studies on the organism (as *Habrobracon juglandis* (Ashmead)) for over 30 years (Martin, 1947). Important factors in the maintainance of braconid stocks which should be of interest to both groups of biologists concern the behavior of males in the presence of possible mates and in the presence of potential food.

Grosch (1947, 1948) found evidence of an olfactory basis in mating behavior. When a search of the literature failed to disclose olfactometer experiments with *Microbracon* males, experiments using olfactometer apparatus were instituted to investigate mating attraction. Also, with the same equipment, investigation was extended to a survey of the attractive ability of various substances which might give clues to male food preferences. Thus the present report gives information bearing on the basic question: What objects are sufficiently attractive to cause a male wasp to seek them? In addition, specific methods of investigation are developed and observations are presented on correlative behavior in starved and unstarved males.

MATERIALS AND METHODS

The normal type of males which are produced parthenogenetically as haploids were used in all experiments. To obtain these impaternate males, virgin females of an eugenic wild type strain were placed with healthy host caterpillars. Ten days later during the expected time of emergence from cocoons, culture vials were examined morning and evening. Males which had emerged since the preceding examination were removed and placed in separate containers labelled with the time and date of collection. Thus the age of males within a group was known to the nearest 12 hours.

Cultures were maintained and all experiments were performed in a windowless cubicle (6x5x7 ft.) the temperature of which was maintained at $86° \pm 1°$ F. A maximum-minimum thermometer was used to record temperature. To guard against dried atmosphere a dishpan was kept filled with water from a dripping tap. Attempts to record humidity were not made but no change from these standard culture conditions occurred during the series of experiments.

Representative types of Y-tube olfactometers (see Peterson '47) were made available by Dr. W. M. Kulash of the North Carolina State College Zoology and Entomology Department. Use of the equipment

was reluctantly discontinued after repeated attempts to set up satis-factory systems failed. Various difficulties prompted this decision. In the first place (1) male wasps were found to have an extremely strong "escape" instinct. That is, they can and will force themselves out of an experimental system through very small crevices. This makes a suction outlet undesirable, for, even when plugged with cotton, any passage which allows entrance of a draft of air enables males to leave the field of investigation. Secondly (2), shadows or dimness act as barriers to free movement. Males are definitely slowed and sometimes even stopped by areas of shade or shadow. This fact argued against the use of a light source to furnish the stimulus to bring test wasps to the place of choice. Furthermore, (3) starved males when first freed in a system are too active to serve for orientation records. They give the impression of indiscriminate trial and error exploration for an escape route. (4) Males are found to walk rather than fly in containers. Thus a two dimensional route is followed on the walls of the experimental system. This is reflected in a definite correlation between the side of the lead tube traveled and the arm into which the wasp turned at what was intended to be a point-of-choice. For this reason direction of first turn is of little value except perhaps with the small number of animals which pause at the point of choice.

With these considerations in mind a closed system was developed which could be used in the dark. This consisted of a simple T-shaped tube which was clamped with the center arm in the vertical position. To the lower end of the vertical arm was attached a vial containing test males. The male wasps reacted by negative geotropism to move up the vertical tube (60 mm. in length) to the point of choice from which horizontal arms (each 60 mm. in length) lead to trap vials. Odorous materials to be tested were placed in one or both trap vials. These trap vials (15 by 70 mm.) were fitted with corks carefully bored to receive an end of the horizontal tube. With the tubing attached, the vial was corked with a square of gauze so fitted that the edges are tightly held between cork and vial but a slack barrier of gauze extends into the vial. This functions as a one way valve. Wasps can force themselves into the trap because the gauze is held firmly against push-ing movements in that direction. Escape is not easy because the gauze is thrown into loose folds if an animal attempts to push through in the opposite or "out" direction.

After a desired period of time the lights can be turned on briefly to enable the recording of the number of wasps in each trap. If sufficient numbers are employed, the distribution of males should indicate an attraction or repulsion by the presence or absence of a significant num-ber of animals with the test material, or the lack of directive stimulus by random distribution.

The T apparatus was first used with females as the lure in one trap and nothing in the other. This and all the following experiments were run for four hours. At the beginning of each experiment the light remained on for five minutes in order that observations might be made which could be compared with those on behavior in Y tube apparatus. The second series of tests compared the reactions of males when honey, a routine laboratory food, was present in one trap and females were

appraised as the lure in the other.   By employing males of known age, the effect of starvation on the behavior of males was considered in this set of experiments.   Groups used were unfed males 1, 2, 3, 4, 5, and 6 days old.

After the honey-vs.-female experiments a qualitative survey was made of the attractent-repellent ability of a representative series of odorous substances by placing the material in one trap vial and having the other trap empty.   Sweet substances, fermentation products, fruits, flowers, and a miscellaneous series of odorous materials were thus screened.   The assortment of fruits and flowers available was limited by the time of year (spring) at which the experiments were performed. A general plan was to include at least one member of each class of the odors catalogued in Moncrief (1946), Chapter 18, entitled "Classification of Odours."

Dilute suspensions, needed when testing strongly aromatic compounds, were made by violently mixing 0.1 cc. of the material with 10 cc. of distilled water.   A drop from the end of a dissecting needle was immediately placed in the desired trap vial before the suspension separated.   If more permanent dilutions are desired a stabilizing agent (such as gum tragacanth) should be employed to maintain suspension. Because the present survey was intended to be only qualitative in nature the dilutions were merely the means of delivering a very small amount (or, in the case of alcohols, a graded series of amounts) of a given substance.   No importance is meant to be given to the absolute quantitative value of the dilution.

After a test, apparatus had to be washed, dried, and aired thoroughly before re-use.   Furthermore, tests run with used squares indicate that gauze squares should be discarded after each test in order to eliminate confused results due to residual odor.

RESULTS AND CONCLUSIONS

Females as the lure.—Summarized results for five tests using day-old males (10 per test) show 14 males in the trap with females, 16 males in the lureless trap, and 20 males scattered at random in the T tube and the original vial.   This random distribution occurred in spite of the fact that before the light was turned off a majority of males (73%) flipped their wings in the characteristic manner known as the mating reaction (Whiting 1932) at the mouth of, or within the tube leading toward the trap containing females.   These mating reactions were followed by excited ambulatorial movement which however was not consistently directional.   (Incidentally, comparable indications of recognition of female presence had been observed in classic Y tube apparatus.)

Starved males used in a similar series of experiments gave similar results.   That is, no significant number of males were attracted into the female vial and the observed distribution appeared to be at random.

A series of experiments in which males were offered the choice between a trap vial with 10 females and a trap vial with a small drop of honey gave the following results.   Day-old males (10 in each of five tests) after 8 hours of darkness were found distributed as follows: 23 males with females, 22 males with honey, 5 males not in traps.   This

random distribution in the traps seems comparable with the female-*vs.*-zero trap vial results above. When starved males were used, striking differences were found in resultant distributions. All the males were then found in traps, and, as starvation increased, more and more males were found with the honey. Summarized results for five experiments at each age:

For 2-day-old males: 30 in honey trap, 20 in female trap.

3-day	34	16
4-day	43	6
5-day	50	0

After 6 days or more of starvation males showed signs of weakening and some died. Although their reactions were limited by their failing strength they were extremely excitable. In one case, three males which had been starved for 6 days were able to make such rapid and apparently effective directive movements that they entered the honey trap and began feeding within the first second after introduction into the system, even before the light was turned out.

In order to see what might happen if starved (5 days) males passed close to females during their movements, gauze barriers were omitted from trap mouths and the light kept on while observations were made in an additional experiment. Six of the males came up the vertical arm of the T in the first five minutes; after slight hesitation four of them turned down the tube leading toward the honey. The other two had not hesitated (had not made a choice?) and their movements followed the surface on which they were progressing. This led them into the female arm. After a few millimeters one male stopped, waved his antennae as if testing the air, then turned to go in the direction of the honey. Meanwhile three females had emerged from their vial and had approached within 6 mm. of him. Suddenly he stopped, flipped his wings in the mating reaction, rushed to a female, mounted and copulated. The second male by this time also recognized the presence of females by giving the mating reaction and attempted to mount the same female. The two unmated females moved on toward the honey. When they came within 6 to 10 mm. of the other five males these also turned, gave mating reactions and attempted mating. It seems worthy of note that all these mating activities occurred before the starved males had fed. After these observations had been made the light was turned off and the system remained in the dark for four hours. At the end of that period it was found that the males had remained in the honey vial while the females had moved *down* to the lowest location in the experimental system. This was the original male vial reached by way of the vertical tube.

Attraction to various materials.—Tables I and II present the summarized results of a qualitative survey on males starved 5 days. For cases in which the total number of wasps recorded in both test traps is shy of the total males tested, the number lacking had not entered the traps. Usually these males were found in the original male vial.

In many cases the results show certain consistent deviations from a random assortment. The chi-square test can be applied to questionable cases where inspection does not suffice. It is evident that honey proved

to be the most powerful attractent while beeswax did not have similar attributes. Karo sirup and molasses were almost equal to honey in attractent potency but fresh sugar sirups lacked similar ability. Along with these observations it was interesting to find that a faint alcoholic odor attracted *Microbracon* males but acetic acid, acidic fluids, and sour fruits did not. The wines used had odors which for human sense of

TABLE I

Distribution of Males in Olfactometer Trap Vials

Ten tests—total 50 males in each experiment

Materials Tested	No. with Material	No. in Zero Trap
Sweets		
Honey	42	8
Karo	40	10
Molasses	38	9
Brown sugar sirup	21	29
Sucrose sirup	26	24
Milk chocolate	17	33
Fermentation Products		
Alcohol (Ethyl) 95%	10	40
Alcohol (Ethyl) 70%	12	38
Alcohol (Ethyl) 50%	28	20
Alcohol (Ethyl) 30%	32	18
Alcohol (Ethyl) 5%	38	12
Acid (Acetic) 0.1%	0	33
Wine (Scuppernong) 14% Alcohol	14	36
Wine (Sherry) 20% Alcohol	0	30
Vinegar (Cider) conc.	0	50
Vinegar (Cider) 0.1%	28	22
Fruits		
Strawberry (fresh)	16	34
Strawberry (sour)	0	50
Banana (fresh)	26	25
Banana (sour)	0	43
Apricot (dried)	31	19
Fig (dried)	30	8
Date (dried)	30	18
Flowers		
Clover (white)	8	42
Rose (red)	0	50
Privet	0	50
Wild Carrot	6	42
Honeysuckle	0	50

smell completely masked any odor contributed by a low alcohol content. A similar effect for the insects would possibly explain why the substances did not prove attractive. Flowers available at the time of the year when the experiments were made, although frequented by bees and other insects had no attractent power for *Microbracon* males. None of the miscellaneous odors, with the possible exception of oil of bergamot

(dilute), attracted males. In fact, cases in which all males are in the zero trap may be interpreted as indication of repellent action.

Used gauze squares when tested for residual odor showed a positive attraction with honey, karo and molasses and a repellent action with such substances as proved repellent in Tables I and II except in the case of terpineol (lilacine). The residual odor of this substance proved attractive in the extremely faint odor given off by the used gauze.

Conclusions on male food habits.—Present evidence on behavior of *Microbracon* males indicates that on the basis of olfactory attraction the source of food is limited to a single type-group comprising rich sirups and sirupy fruits. Attractiveness of a faint odor of ethyl alcohol

TABLE II

DISTRIBUTION OF MALES IN OLFACTOMETER TRAP VIALS

Two tests—total 20 males in each experiment

MATERIAL TESTED	NO. WITH MATERIAL	NO. IN ZERO TRAP
Miscellaneous		
Amyl-acetate (dil.)	0	19
Balsam (flakes)	10	10
Beeswax (flakes)	11	9
Bergamot Oil (dil.)	12	6
Cedar Oil (dil.)	0	20
Cheese (mild Amer.)	0	18
Clove Oil (dil.)	0	15
Coffee (ground)	10	10
Lemon Oil (dil.)	5	15
Meat (decomposing)	0	19
Menthol (crystals)	0	20
Peppermint Oil (dil.)	0	20
n-Propyl Formate (dil.)	0	20
Quinoline (dil.)	7	13
Sassafras Oil (dil.)	8	12
Spearmint (leaf)	0	20
Tar (flakes)	0	20
Terpinol (dil.)	0	20
Vanilla (extract 37% alcohol)	6	14
Yeast (cake fragments)	7	13

is consistent with this grouping because insects which feed on natural sirups are accustomed to encounter primary products of fermentation (Dethier 1948). This may hint at the common basis of attraction shared by these enumerated potential food substances. It seems possible that their attractive principles are associated with sugar decomposition even prior to alcohol formation. At any rate this is true in the case of the codling moth, another sirup feeder for which the appearance of acid renders a fermenting mixture repellent (Eyer 1931, 1934). The sirup feeder is quite different in habit from the frequenter of fermenting substances. The fruit fly, *Drosophila*, is an example of the latter. Acids and acetates enhance bait attractiveness and *Drosophila* find cider vinegar and sherry wine very attractive (Barrows 1907) while *Microbracon*, as shown herein, do not.

Sugar content, presumably valuable from the standpoint of utilizable nutriment, is valueless in attracting *Microbracon* males. Olfactory response is lacking with fresh sugar solutions. Successful laboratory feeding of braconids with sugar water seems to depend on a recognition of food by taste and therefore must involve contact stimuli. Sirups (such as honey) which attract from a distance should be more efficient in feeding cultures. If sugar water is the only food available, routine use of small culture vials is recommended in order to favor chance contact with the food.

It is unlikely that males in their normal habitat find food in granaries, flour mills, and similar establishments. Furthermore, they are unable to continue sustained flight to other buildings more likely to contain stored sirup. However, since 5 days of starvation were found to merely increase activity it seems that there is sufficient time during which any available females will be found even by undirected male explorations. In commercial buildings where miscellaneous foodstuffs are stored, success in finding food is more likely. Hamid (1940) has presented similar conclusions.

Non-specific mating reactions.—To distinguish unexplained wing-flipping in the absence of the female or female products, Grosch (1948) suggested the term "non-specific mating reaction." The simplest hypothesis offered in explanation was that non-specific mating reactions were nonpurposive expressions of excitable male reactivity. Observations during the present series of experiments seem consistent with such an explanation. By an avoiding reaction aromatic oils are shown to be repellent, yet when a vial of males is plugged to a test system which contains strong odorous oils a common male reaction is wing flipping similar to that of a true mating reaction. This was especially noticeable with clove oil and was more pronounced and unanimous when concentrated oil was used. Concentrated oil is not suitable for test conditions it was discovered early in preliminary experiments. Males exposed in closed system show high mortality and therefore irritant action of its fumes is suspected. Dethier (1948) points out the interesting parallel that the odor of clove oil quickly kills ants.

DISCUSSION

The escape instinct of small wasps necessitates the use of tightly closed systems when working with the animals. Furthermore since access to stored foods is likely to be by way of minute passageways, the use of closed systems involving tubing of a relatively small diameter seems applicable to investigations of food habits. However, graded intensity of stimulus cannot be well maintained and therefore closed systems seem unsuited for investigations of mating attraction. Mating reactions which apparently are specific, indicate some perception of female presence in the system, yet subsequent random distribution of males implies a failure in the attractive mechanism. It seems that unless the male is relatively near the female, perception of her presence increases trial and error exploration of the system rather than leads him directly to her. These observations in the present apparatus are consistent with observations on smaller closed systems already reported (Grosch 1948).

In order to make an indirect check on the efficiency of mating attraction ten simple tests were made using a 32 oz. jar (height 240 mm., diameter 160 mm.), the largest closed container available. Compared with the size of the animal (length 2 mm.) this is a comparatively large volume which should make chance of meeting improbable. For each test a single virgin was placed in the jar with a single male and the closed jar immediately stored in the dark for 4 hours. At the end of that time the animals were removed and the female was given host caterpillars. In all cases the hosts were parasitized successfully, and when adults appeared the occurrence of biparental offspring indicated satisfactory mating in each test. Does this indicate that a graded intensity of olfactory stimulus can obtain and function adequately in a closed container of relatively large volume?

Unfortunately the chemistry of insect sex scents is virtually unknown (Dethier 1948). In fact no sure human identification of insect sex scent has been reported even in cases as well grounded as certain of the Lepidoptera. Undoubtedly braconid female scent is delicate and tenuous, yet it was interesting to see males which were seemingly intent on reaching honey turn and make directly for females when the potential mates had come within what appears to be the most effective radius of the stimulus. Instead of the conclusions that hunger drive is stronger than mating attraction, an inference which would be made on the basis of trap vial results, these mating attempts by unfed males indicates a possibility that a heavy scent such as honey has a masking effect on sex scent. Strength of the effective stimulus of female scent increases with decreased distance so that mating is observed to be the strongest drive with a suitable strength of stimulus. This involves a relatively close approach of the animals before the attractive mechanism functions effectively. However, in the normal habitat when males and females congregate at a sirup supply a combination of events similar to these observed with females freed in the test system could be an efficient means of perpetuating the wasps.

SUMMARY

1. After unsatisfactory trials with air-draft, light-source olfactometers, a closed system was adopted which should be used in the dark. Negative geotropism of the males is used to bring them to the point of choice. This method is probably not applicable to investigations with females because they are suspected to react by positive geotropism. Difficulties with classic olfactometers are listed.

2. Although males gave some recognition of female presence by wing flipping and an increased rapidity of movement, directive attraction did not function effectively. This is consistent with other findings with closed systems of limited dimensions. In contrast, when a relatively large closed container was used, males unfailingly found virgin females for successful mating. This was evidenced by the biparental offspring produced.

3. Starving males were definitely attracted to honey, karo, molasses, and sirupy fruits. This reaction was more pronounced with greater length of starvation time. Fresh sirups made with simple sugars had no attractive power. A faint odor of alcohol (ethyl) proved attractive

while acetic acid, acidic fluids, and sour fruits were repellent. Flower odors and a representative series of aromatic materials were unattractive. It is concluded that food interest may be limited to a single type-group and suggested that the primary break-down products of sugar decomposition may furnish the attractive principles.

4. Starved males mated with females before feeding if the distance between animals chanced to narrow to less than 10 mm. Contact stimuli were not involved in preliminary attraction.

5. In cases of irritation by aromatic fumes, non-specific mating reactions were observed. This contributes to the hypothesis that these non-specific reactions are nonpurposive expressions of an excited state.

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THE MAYFLIES OF FLORIDA, by Lewis Berner. Univ. Florida Studies, Biol. Sci. Series, vol. 4, no. 4, xii+267 pages, frontispiece, 19 maps, 88 textfigures, 24 plates. 1950. Price, $5.50.

The title of this work may imply that it is a taxonomic study, but actually it is much more than that. A glance at the work is sufficient to indicate that the author gave considerable time and effort to the study of distribution, ecology, habits, and life histories of these insects. This work, consequently, will be of considerable interest to the ecologist, the limnologist, and the aquatic game biologist.

A collection of fifty thousand specimens, made from all parts of the state, and over a period of seven years, supplied the taxonomic material. The keys, illustrations, and the brief section devoted to taxonomy under each species, should serve to identify the species, several of which, however, are indicated only by key letters or numbers. It is noteworthy that the key to the nymphs includes all species discussed in the text except one of rare occurrence. It is gratifying to learn that a fauna could be so thoroughly known in its immature stages.

The work presents a very good appearance. It is well printed on a good-grade, smooth paper, which is not, however, so glossy as to produce eye-strain. The half-tone plates are reproduced well, and the maps present at a glance the distribution within the state. A list of references (pp. 255–259) and an index are included.

—M. T. J.

THE GENUS SCOPEUMA IN THE WESTERN UNITED STATES AND SOUTHWESTERN CANADA[1]

(Diptera, Scopeumatidae)

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Malloch (1935) reviewed the New World species of *Scopeuma* (as *Scatophaga*) and included in his review, for purpose of comparison, a discussion of some related Old World forms. His work has, for the most part, been quite serviceable for the identification of American species. The purposes of the present paper are mainly to clarify some matters in regard to synonymy, to present the description of a new species, to discuss distribution, variation, and relationships, and to present a key which, though borrowing much from that of Malloch, should prove somewhat more serviceable for the area covered and at the same time help to indicate relationships.

The name *Scopeuma* was proposed by Meigen (1800), with inclusion of seven species, none of which was indicated by name. Later, Meigen (1803) discarded that name and used in its place *Scathophaga*, with but one included species, *Musca merdaria* L. Coquillett (1910) designated *M. merdaria* as the type of *Scopeuma*, thus making the two names absolute synonyms (*Scatophaga* is merely an emendation of *Scathophaga*). Curran (1934), therefore is not justified in using the name *Scopeuma* for those species with the pteropleura hairy and *Scatophaga* for those with the pteropleura bare.

Malloch characterizes the genus as follows: "Sternopleura with one strong posterior bristle; stigmatal and propleural bristles not or poorly differentiated from the adjacent hairs; palpi without a long apical bristle; fore femur without anteroventral bristles; fore tibia without short stout ventral setulae, and without a well-developed preapical anteroventral bristle; hypopygium of male not bearded; first wing-vein bare [;] sixth vein complete."

The present paper deals with the species of *Scopeuma* recorded from the eleven Rocky Mountain and Pacific Coast States, namely, Washington, Oregon, California, Idaho, Montana, Wyoming, Nevada, Utah, Arizona, Colorado, and New Mexico, and from the two Southwestern Canadian Provinces of Alberta and British Columbia. Of the fifteen species treated here, three are extralimital, but are included because of their possible occurrence in the area in question. *S. pallidum* occurs in the Eastern United States, *S. vittatum* in Mexico, and *S. crinitum* on the Alaska coast. It is interesting to note that, while on the one hand three species, *S. furcatum*, *S. suillum*, and *S. stercorarium* are of Holarctic or even wider distribution, one other, *S. orcasae*, is known from only a small island in Puget Sound.

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[1] I am indebted to Mr. Curtis W. Sabrosky for critically reading this manuscript.

This study is based on material from several collections, but particularly from the United States National Museum, the California Academy of Sciences, the American Museum of Natural History, the Chicago Museum of Natural History, the University of Kansas, the University of Colorado, Colorado A. & M. College, the Utah State Agricultural College, the State College of Washington, the University of California, and the University of Idaho.

KEY TO THE WESTERN SPECIES OF SCOPEUMA

1. Pteropleuron with some fine erect hairs on at least a part of its surface...... 2
   Pteropleura entirely devoid of erect hairs............................... 7
2. Arista with some long hairs on the basal half, the longest of these about half the width of the third antennal segment; fifth abdominal sternum of male with posterior angles strongly produced and in addition with a pair of approximate apical median processes; antennae entirely deep black; femora for the most part black; cross-vein r-m infuscated,
   stercorarium
   Arista almost or quite bare, or with hairs which are no longer than its basal diameter; fifth abdominal sternum of male with lateral angles strongly produced and divergent, but without apical median processes... 3
3. Presutural acrosticals weak, arranged in four or more irregular series; abdominal pile short, the erect discal pile usually no longer than third antennal segment and not, or but slightly crinkly; lateral lobes of fifth sternum strongly convex inwardly, consequently diverging U-shaped..... 4
   Presutural acrosticals strong and long, arranged in two series; supraspiracular convexity of pleurotergite[2] downy or pubescent, without outstanding fine erect hairs; abdominal hair, especially in male, long and crinkly, at least some hairs longer than third antennal segment and curled at apex; lateral lobes of fifth sternum feebly convex inwardly, consequently diverging V-shaped.................................... 6
4. Supraspiracular convexity of pleurotergite with erect fine hairs, the longest of which are about as long as the fringe of the lower squama; palpus black, the basal fourth or more usually yellowish..................**molle**
   Supraspicular convexity of pleurotergite downy or pubescent, without outstanding fine erect hairs...................................... 5
5. Palpus blackened on apical half or more, slightly flattened, and rather slender, being distinctly narrower than front basitarsus; abdominal pollen unicolorous; larger species, 4.5 to 6 mm.; adults flying in summer..**griseum**
   Palpus yellow, at most darkened at extreme apex, more flattened, and broader, the maximum width almost equal to that of front basitarsus; abdomen grayish, with the bases and apices of segments two to five inclusively distinctly brownish; smaller species, 4-5 mm.; adults occurring in late fall and early spring..........................**hiemale**
6. Hairs of thorax and abdomen long, fine; acrosticals usually long, slender, hair-like; scutellum normally with more than two pairs of marginals and submarginals; clypeus[3] black, much darker than parafacials, obscured by grayish pollen; legs black, with grayish pollen; palpus slender, but feebly clavate, usually darkened at apex, usually about 1.4 as long as antenna in male, proportionately somewhat shorter in female....**dasythrix**
   Hairs of thorax and abdomen shorter and more bristle-like; acrosticals stout, bristle-like; scutellum with two pairs of marginals and one of discals; clypeus or at least epistoma yellow, more or less obscured by grayish pollen; tibiae usually yellow to reddish-yellow, sometimes infuscated centrally, rarely entirely black; palpus distinctly clavate, entirely yellow, and shorter, not more than 1.2 as long as antenna,
   impudicum

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[2]The convexity above the metathoracic spiracle and before the halter.

[3]The term "clypeus" is used here in the sense in which Townsend employes it, that is, as the middle of the "face," or as the "frontoclypeus" of Comstock.

7.   Hypopleuron with a few long fine hairs on the upper margin in front of the
     metathoracic spiracle; presutural acrosticals sparse and bristle-like,
     biseriate; arista with hairs on basal half, the longest about twice as long
     as the maximum width of the arista..............................**frigidum**
     Hypopleuron bare.. 8
8.   Anterior pair of postsutural intraalars lacking........................... 9
     Anterior pair of postsutural intraalars present, the posterior pair, however,
     sometimes weak or lacking..10
9.   Both pairs of postsutural intraalars lacking; presutural acrosticals minute,
     irregularly triseriate or quadriseriate; wings of normal length, pale
     yellow, the cross-veins not infuscated; antennae largely black; posterior
     portion of thorax between base of abdomen and bases of hind coxae as
     usual for the genus, that is, not evenly convex, the central portion less
     heavily sclerotized than the lateral portion and more or less sunken; male
     hypopygium enlarged, fifth sternum incised medially, with prominant
     lateral processes...**orcasae**
     Posterior pair of postsutural intraalars present; presutural acrosticals
     moderately strong, biseriate; wings exceptionally long, brownish-yellow,
     with the cross-veins infuscated; antennae wholly yellow; posterior
     portion of thorax between base of abdomen and bases of hind coxae
     convex and equally heavily sclerotized for entire width; male hypopygium
     of ordinary size, fifth sternum with paired median but without lateral
     processes..**reses**
10. Arista with some outstanding hairs on the basal half, the longest of which
     are not less than four times as long as the basal diameter, or fully one-third
     as long as the width of the third antennal segment....................11
     Arista bare or pubescent, hairs when present not noticeably longer than the
     basal diameter..13
11. Third antennal segment almost entirely black; palpus on apical half very
     distinctly dilated, more than breadth of third antennal segment; cross-
     veins distinctly infuscated; legs fulvous-yellow, the front femur with a
     blackish streak posteriorly (*palpale* Malloch),
                                  female of **Pseudopogonota aldrichii** Malloch
     Antennae fulvous-yellow, the third segment sometimes slightly brownish
     above and at apex, never black; palpus clavate, not markedly dilated;
     legs entirely yellow..12
12. Occiput on upper half black or blackish, somewhat obscured by yellowish
     to golden pollen; fifth abdominal sternum of male in the middle of its
     apex with a pair of slender, closely-placed processes which are longer
     than wide..**suillum**
     Occiput yellow, at most somewhat darkened in the median area behind the
     ocellar triangle; fifth abdominal sternum of male in the middle of its
     apex with a pair of short, broad, rounded processes.............**pallidum**
13. Femora deep black and conspicuously glossy, the tibiae and tarsi also black;
     fore tarsus very short, the fifth segment almost as long as the first and
     almost as long as the second to fourth segments combined; male usually
     with extremely long orange-yellow crinkly hair on abdomen; bristles and
     hairs on mesonotum long and strong, the presutural acrosticals biseriate
     and setulose or bristly; fifth abdominal sternum of male with its lateral
     angle produced into long tapering processes and without central
     processes..**crinitum**
     Femora never glossy black, if black, then more or less distinctly gray-
     pollinose, or the tibiae are not black; fore tarsus slender, the fifth segment
     much shorter than the first and hardly as long as the third and fourth
     combined; abdomen without dense crinkly hair in either sex; fifth
     abdominal sternum of male with slender median processes and without
     lateral processes..14
14. Inner cross-vein but little beyond apex of first vein; usually the fore femora
     partly blackish, the mid and hind pairs sometimes darkened on the
     posterodorsal surfaces; longest hairs on the arista not as long as its basal
     diameter..**furcatum**
     Inner cross-vein about as far beyond apex of first vein as length of the
     costal division immediately preceding the latter; all femora darkened

on their posterodorsal surface, the mid and hind pairs with a fuscous streak from near base to beyond middle; longest hairs on arista a little longer than its basal diameter..............................**vittatum**

THE SCOPEUMA STERCORARIUM GROUP

Scopeuma stercorarium (Linnaeus)

Musca stercoraria Linnaeus, 1763, Fauna Suecica, second edit., p. 458, no. 1861. Type from Europe.

This species, the most common and widely distributed member of the genus, is the ubiquitous dung fly found so commonly on fresh cattle dung. It occurs throughout much of temperate North America, Europe, and Asia, and into Africa. Though highly variable in appearance because of the variation in the color, extent, length, and density of its yellowish vestiture, it is easy to distinguish from other members of the genus by the characters given in the key. I agree with Malloch that there is no basis for distinguishing *Musca merdaria* Fabricius, a less hairy form but one which shows all degrees of intergrades in the same localities as the more typical *S. stercorarium.*

A peculiar gynandromorph from Giant Forest, Tulare County, California, July 26, 1928 (C. L. Fox), Calif. Acad. Sci., is apparently a female with the postabdomen and genitalia showing male characters. The first four abdominal segments are broad, with the vestiture consisting of short, appressed, black setulae, as in a normal female. The remaining segments are predominantly male, but with female characteristics: the black setulae persist on the fifth and sixth terga though mixed with softer whitish pile; the fifth sternum is prolonged on one posterior angle only, and lacks the median processes; a well-developed though undersized, two-segmented hypopygium is present, both segments of which are shining, the first segment being reddish and the second black as in the corresponding segments of the female, and unlike the normal male condition; the second hypopygial segment is clothed on each side with converging black hairs and bristles; apparently normal, though small, claspers, and an aedeagus are present. A normal male and female, same data except July 18, are of the type corresponding to *Musca merdaria.*

Distribution.—I have records from all eleven Rocky Mountain and Pacific Coast States, from Alberta, British Columbia and Alaska. Farther northward, *S. furcatum* appears to replace it as the most common species.

THE SCOPEUMA MOLLE GROUP

The three species referred to this group are obviously closely related and seem to form a natural complex. The genitalia are of the same type in all three (cf. Malloch, 1935, p. 252, for male and female genitalia).

Scopeuma molle (Becker)

Scatophaga mollis Becker, 1894, Berliner Ent. Zeitschr., 39: 171. Type from Siberia.

This species is very close to *S. griseum,* the best distinguishing characteristic being the soft, long hairs on the convexity of the pleurotergite, above the metathoracic spiracle and before the halter. Crossvein r-m is usually distinctly clouded, and the chaetotaxy is stronger.

Specimens examined.—12 males and females. ALASKA: Matanuska, May 10, 1944, rotary trap (J. C. Chamberlin), U. S. Nat. Mus. COLORADO: Roggen, April 8, 1933, and May 18, 1946 (M. T. James), Colo. A. & M. Coll., and U. Colo. UTAH: Logan, Sept. 9, 1931 (Lowell Cutler), June 11, 1931 (Wylie Thomas) and Oct. 17, 1909; Blue Creek, Nov. 4, 1931 (G. F. Knowlton); all Utah State Ag. Coll.

Malloch has recorded this species from Northwest Territory, Yukon Territory, and Alberta.

Scopeuma griseum (Malloch)

Scatophaga grisea Malloch, 1920, Proc. Ent. Soc. Washington, 22: 34. Type locality, Logan, Utah.

A larger and more robust species than *hiemale*, from which it may readily be separated by the key characters. The brownish markings of the thorax, especially on the mesonotum, are more slender and less conspicuous, and the abdominal pollen is unicolorous. The chaetotaxy is essentially as in *hiemale*, though tending to be better developed. The front femur is a little shorter than in *hiemale* and tends to taper more apically.

Specimens examined, 163 males and females.—CALIFORNIA: Bishop, July 28, 1940, Lake Tahoe, July 11, 1940, and Lone Pine, July 28, 1940 (all L. J. Lipovsky), U. Kansas. COLORADO: Lindland, July 27, 1938, Cowdrey, July 27, 1938, Nederland, July 9, 1932, Grizzly Creek Camp Ground, Jackson County, July 17, 1946, and Rand, July 18, 1946 (M. T. James); LaVeta Pass, Aug. 5, 1938 (M. T. James, Urless Lanham), Colo. A. & M. Coll.; North Park, 9000 ft., July, Chicago Mus. N. H. IDAHO: Succor Creek, July 30, 1926 (R. W. Haegele) and Mackay, July 7, 1926, U. Idaho. MONTANA: Beaver Creek, 6300 ft., August, 1913 (S. J. Hunter), U. Kansas; Bennett, Aug. 12, 1931 (R. H. Beamer, J. Nottingham), U. Kansas. NEVADA: Wells (allotype); Wells, June 3, 1940 (M. T. James), Colo. A. & M. Coll.; Carson City, Aug. 9, 1929 (P. W. Oman), U. Kansas. CALIFORNIA: Blue Lake, Lassen County, July 12 to 20, 1947 (T. F. Leigh), U. Calif. OREGON: Anthony Lake, July 11, 1931 (R. H. Beamer and students), U. Kansas; North Powder, July 13, 1931 (J. Nottingham), U. Kansas; Dixie, July 8, 1931 (Beamer), U. Kansas; Haines, July 30, 1931 (L. D. Anderson), U. Kansas; Klamath Falls, May 8, 1924 (C. L. Fox), Calif. Acad. Sci. UTAH: Logan (type); Heber, Aug. 17, 1940 (Beamer), U. Kansas; Altus, June 26, 1940 (James), Colo. A. & M. Coll.; Logan, May 28, 1947 (M. Varzendeh) and Aug. 23, 1907 (E. G. Titus), Utah State Ag. Coll.; Logan, Aug. 15 and 18, 1922 (E. P. Van Duzee), Calif. Acad. Sci.; Logan Canyon, June 6, 1938 (W. P. Nye), Aug. 14, 1943 (G. F. Knowlton, D. R. Maddock), and Sept. 21, 1942 (Knowlton, S. L. Wood), Utah State Ag. Coll.; Ephraim, June 15, Utah State Ag. Coll.; Plain City, June 14, 1929 (Knowlton, R. S. Roberts), Utah State Ag. Coll.; Mt. Nebo, Aug. 14, 1943 (Knowlton, Maddock), Utah State Ag. Coll. WYOMING: Hunters Creek, Sept. 11, 1895, Lusk, Aug. 26, 1895, and Two-gwo-tee-a Pass, Sept. 12, 1895 (all Hough Collection) Chicago Mus. N. H.; Lusk, July, 1895, Horse Creek, August, 1895, and near Lander, 5000 to 8000 ft. (Roy Moodie), U. Kansas; Snowy Range, near Centennial, Aug. 15, 1938 (M. T. James), Colo. A. & M. Coll.

Scopeuma hiemale, new species

Male.—Background of head mostly black; frontalia, at least on anterior half, and an adjacent area of each parafacial opposite bases of antennae, reddish-yellow; parafacials, clypeus, and oral margin yellow; background obscured by dense grayish pollen which is lightest on the frontalia but which almost completely obscures the coloration of the clypeus and lower parafacials. Comparative head measurements of holotype: head width, 93; head height, to oral margin, front view, 60; width of vertex, 42, of front opposite lunule, 36, anterior ocellus to lunule, 26; lunule to oral margin, 35; distance between major vibrissae, 28; width of parafacial, 4, of parafrontal above lunule, 5, of parafrontal opposite anterior ocellus, 12; length of antenna 30, of arista, 35, of palpus, 30; palpal width at base, 2.5, before apex, 4.5. One pair each of ocellars, inner verticals, and outer verticals, all strong and clearly differentiated from adjacent setulae; postocellars short but distinct; one proclinate and two reclinate pairs of frontoorbitals; usually four pairs (sometimes a fifth) of convergent frontals; one pair of cruciate vibrissae, with a shorter vibrissa above and one below on each side, and with a group of short bristles adjacent; normally no bristles on cheeks. Occipitoorbitals extending a little below middle of eye; a few scattered bristles, arranged mainly in a row on each side, on upper half of occiput. All bristles of head black; a few scattered black setulae on ocellar triangle, occiput, and vertex; pile of cheeks and lower part of occiput silky whitish.

Antenna deep black; second segment with some black setulae and an outstanding, though short, black bristle; arista black, thickened on basal third, with a few short appressed black hairs on first and thickened part of second segment. Palpus wholly yellow or at most slightly infuscated apically, grayish-pollinose, spatulate, mostly whitish-haired, but with a few stiff black hairs at apex.

Thorax black, obscured by grayish pollen variegated with brownish as follows: two broad vittae just inside the dorsocentral rows; two of similar breadth inside the intraalars, interrupted at the suture and reaching neither the humerus nor the postalar callus; and a stripe of similar breadth extending across the lower part of the humerus, across the mesothoracic spiracle, behind which it is interrupted, and almost to the posterior margin of the mesopleuron; these are much broader and more prominent than similar areas in *S. griseum*. Stronger bristles arising from distinctly brownish rings. Acrosticals hair-like, in about four irregular rows. Normally one pair of postsutural intraalars (the first), the second sometimes feebly developed, two pairs of marginal scutellars, and no discoscutellars, though one pair of the latter may be feebly developed. Stigmatals and propleurals absent. Propleura hairy. Five or six fine whitish hairs on each pteropleuron. Bristles, acrostical hairs, and mesonotal setulae black; pleural pile soft, whitish. All pile and setulae short, longest on sternopleura, where they are one-half to two-thirds length of antennae.

Legs robust; front femur much thicker than middle and hind ones. Coxae, trochanters, and femora, except apices, black, rest of legs yellow, all with dense grayish pollen, especially on the black areas. Chaetotaxy

of legs variable, but the apparent normal condition is: middle femur with one posterodorsal preapical and one posterior preapical; hind femur with an irregular row of four to five anterodorsals; fore tibia with a long median dorsal, a posterodorsal row of four or five, and a median preapical posteroventral; middle tibia with an anterodorsal, a posterodorsal, and a posterior; hind tibia with two median and one preapical anterodorsals and two median and one preapical posterodorsals. Pile of tibiae, tarsi, and apices of femora stiff, black, that of coxae and femora, except apices of latter, soft, whitish; halteres and calypters, with their fringe, yellow; wings without clouding or slightly clouded on the cross-veins, yellowish at base; veins yellowish basally, brownish apically; veins R_{4+5} and M_{1+2} somewhat convergent, then parallel at extreme apices.

Abdomen black, obscured by dense pollen which is mostly grayish but which is distinctly brown at the broad bases and apices of terga two, three, four, and five; pollen of apical segments tending to brownish apically. Pile of first and second terga, sides of other terga, and of sterna, soft, whitish, a little longer than on thorax but by no means dense or crinkly, longest on sides of second segment; terga otherwise with black setulae; second to sixth terga each with a row of weak marginal bristles. Fifth sternum deeply incised medially, the arms extending U-shaped; no median processes.

Length, 4–5 mm.

Female.—Essentially as in the male, except sexually. Bands of brownish pollen on abdomen not quite so broad as in male. Last tergum appearing blunt and rounded from dorsal aspect.

Holotype, male,—Cimarron River, 28 miles south of Walsh, Colorado, May 23, 1947 (M. T. James); State College of Washington Type Collection No. 170. *Allotype*, female.—East Carrizo Creek, Las Animas County, Colorado, May 23, 1947 (James). *Paratypes:* 14 males, 5 females, East Carrizo Creek, Colorado, May 23, 1947 (James); 1 male, 1 female, 28 miles south of Walsh, Colorado, May 23, 1947 (James); 5 males, 1 female, Roggen, Colorado, November 24, 1945 (James); 1 female, Roggen, Colorado, May 27, 1937 (M. & H. James); 1 male, Fort Collins, Colorado, May 3, 1946; State Coll. Wash. and Colo. A. & M. Coll.

THE SCOPEUMA LITOREUM GROUP

The close relationship of *S. dasythrix* and *S. impudicum* to the European *S. litoreum* (Fallén) is quite apparent, even to the point that some question may exist as to the specific distinctness of the three. *S. frigidum* and *S. crinitum*, two well-marked species, are being placed here provisionally, as they share with the *litoreum* complex such characters as the dense hairiness and crinkly pile, the long biseriate acrosticals, the strongly developed chaetotaxy, and the similar genitalia, as well as having likewise a littoral habitat.

Scopeuma dasythrix (Becker)

Scatophaga dasythrix Becker, 1894, Berliner Ent. Zeitschr., 39: 173.   Type from Bering Strait.

As Malloch has pointed out, this species is very close to both *S. islandicum* (Becker) and the European *S. litoreum* (Fallén). Typically

it is the hairiest member of this complex of three species, the long, crinkly hair of the abdomen of the male being blackish above, yellow below, and appearing as a whole grayish to the naked eye. The female is hairy for that sex, with crinkly pile on the pleura, sterna, and legs. The male from Neskowin, Oregon, is much less hairy than the Alaskan males, in this respect, except for the abdominal terga, being more like the Alaskan females.

Specimens examined.—99 males and females. ALASKA: St. Paul Island, June 20, 1920, July 4, 1920, and July 13, 1917 (G. D. Hanna), April 13, 1913 (A. G. Whitney), and July to August, 1921 (A. Christofferson), Calif. Acad. Sci. and U. S. Nat. Mus.; St. George Island, June 4 and 16, 1914, and July 1, 1920 (Hanna), Calif. Acad. Sci. and U. S. Nat. Mus.; Atka Island, Aug. 1, 1907 (E. C. Van Dyke), Calif. Acad. Sci.; Seward, June 15, 1937 (C. B. Philip), State Coll. Wash.; Douglas, Aug. 2 and 9, 1901 (Elred Jenne), State Coll. Wash.; Amchitka Island, July 5 and 8, 1937, U. S. Nat. Mus.; Kodiak, 1935, Towns Coll., U. S. Nat. Mus. OREGON: Neskowin, Aug. 10 to 17, 1948 (M. T. James), State Coll. Wash.

Scopeuma impudicum (Reiche)

Anthomyia impudica Reiche, 1857, Bull. Soc. Ent. France, v, p. ix.
Scatophaga Islandica Becker, 1894, Berliner Ent. Zeitschr., 39: 175. Types from Iceland and Labrador.
Scopeuma impudicum (Reiche), Sack, *in* Lindner, 1937, Die Fliegen der Palaearctischen Region, 62a, p. 61 (synonymy).

I have seen four males and two females, Larrabee State Park, near Bellingham, WASHINGTON, July 17, 1949 (M. T. James); in addition to this I have records from Labrador, Nova Scotia, Quebec (Gaspe Bay and Bradore Bay), and Alaska. Malloch has reported this species from Churchill, Manitoba, and from the Pribiloff Islands.

Scopeuma frigidum (Coquillett)

Scatophaga frigida Coquillett, 1900, Proc. Washington Acad. Sci., 2: 454. Types from Kukak Bay and Popof Island, Alaska.

According to Malloch (1935), this species was, at the time he wrote, known only from the types (two males and one female, Kukak Bay and Popof Island, Alaska). I have seen a male, Adak, Aleutian Islands, ALASKA, Aug. 3, 1947 (D. W. Jenkins), U. S. Nat. Mus., and a female, Unalaska, ALASKA, Sept. 10, 1920 (G. D. Hanna), Calif. Acad. Sci., which conform with the original description. The fifth sternum is essentially as in *S. crinitum* (cf. Malloch, 1935 p. 259, fig. 18), but at least the lateral apical processes are yellow. I have seen two males, Newport, OREGON, June 8, 1925 (E. C. Van Dyke), Calif. Acad. Sci.; three males, Smith River, CALIFORNIA, July 12, 1930 (J. M. Aldrich), U. S. Nat. Mus.; one male and one female, Crescent City, CALIFORNIA, July 10, 1930 (Aldrich), U. S. Nat. Mus.; one female, Carmel, CALIFORNIA, Oct. 16, 1921 (L. S. Slevin), Calif. Acad. Sci.; and one male, one female, Hermosa Beach, CALIFORNIA, March 18, 1941 and May, 1938, U. Calif. These seem to be clearly conspecific with the Alaska specimens, but are paler; the coxae and tibiae tend to be more brightly

yellow, the femora tend to be broadly yellow basally and apically, though with some variation in this respect, the fifth sternum in the male may be almost entirely yellow, and the pale pile, particularly on the abdominal venter, is more brightly yellow.   The length varies from 5 mm. (Crescent City) to 10.5 mm. (Newport), the Alaska specimens being intermediate.

Scopeuma crinitum (Coquillett)

Scatophaga crinita Coquillett, 1901, Proc. U. S. Nat. Mus. 23: 612.   Type from Bering Island.

The glossy black femora and the shortened front tarsi distinctly characterize this species, although there is a tendency for the front tarsi to become shortened in some species, *S. frigidum* for example.   The acrosticals are strong and bristle-like; there are usually four or five postsutural intraalars and five or six postsutural dorsocentrals, thus making the mesonotum conspicuously bristly.   In typical males, the abdomen is covered with dense, furry, crinkly, yellow pile; this is the hairiest species discussed in this paper.

I have seen about two hundred specimens from coastal and island localities in Alaska.   This species probably does not extend southward into our area.

THE SCOPEUMA ORCASAE GROUP

Scopeuma orcasae (Malloch)

Scatophaga orcasae Malloch, 1935, Ann. Mag. Nat. Hist. (10)15: 265.

Malloch states that this is an aberrant species, but that on the basis of the present definition it must go in this genus.   The type and allotype are from Mt. Constitution, Orcas Island, Washington, July 7, 1905.

THE SCOPEUMA RESES GROUP

Scopeuma reses (Giglio-Tos.)

Scatophaga reses Giglio-Tos, 1893, Boll. R. Univ. Torino, 8: 158.
Scatophaga suilla var. *mexicana* Malloch, 1935, Ann. Mag. Nat. Hist. (10)15: 258, (new synonymy).

Malloch's holotype of *mexicana*, U. S. National Museum No. 50445, is simply a slightly teneral specimen of *reses*.   In couplet 20 of his key, Malloch separates three species, namely *scybalaria* L., *reses* G.-T. and *amplipennis* Portschinsky from the species of the following couplets, including *suilla* s.s. and *suilla* var. *mexicana*, on the basis of the convexity and heavy sclerotization of that part of the thorax lying between the abdomen and the hind coxae.   In the type of *mexicana*, this portion is damaged, but is apparently concave; this concavity, however, as well as the lack of clearly defined dark tergal apices, seems to be due to the teneral condition of the specimen.   Contrary to Malloch's statement, the posterior intraalar bristle is present.

Specimens examined.—62 males and females. NEW MEXICO: Cloudcroft, June 27, 1940 (R. H. Beamer, D. E. Hardy), Magdalena, and from Magdalena Mts., Aug. 1894 (Snow), U. Kansas. ARIZONA:

Chiricahua Mts., June 9, 1933 (Beamer), U. Kansas. MEXICO: Mt. Tancitaro, Michoacan, 1941, 7800 ft., (H. Hoogstraal), Chicago Mus. N. H.; 43 km. S. of Mexico, D. F., 9480 ft., June 20, 1948 (W. Nutting), State Coll. Wash.

This species has been recorded from Guatamela by Malloch.

THE SCOPEUMA SUILLUM GROUP

This is a group of slender species with slender legs, not especially conspicuously hairy bodies, and a similar type of male genitalia. The fifth sternum bears a pair of approximate slender or rounded median processes, but is without lateral processes.

Scopeuma suillum (Fabricius)

Musca suilla Fabricius, 1794, Entomologia Systematica, vol. 4, p. 343.   Type from Europe.

This Holarctic species seems to be widespread, though not common, in the northern part of our range, and thence northward to Alaska.

Material examined.—About 35 males and females. BRITISH COLUMBIA: Merritt, U. Kansas. WASHINGTON: Ilwaco, May 16, 1918 (A. Spuler), State Coll. Wash; Quinault and Republic, U. Kansas. OREGON: Neskowin, Aug. 10-17, 1948 (James), State Coll. Wash. MONTANA: Missoula, U. Kansas. UTAH: Logan Canyon, Sept. 16, 1934 (T. O. Thatcher), Utah State Coll.; Hole-in-Rock Canyon, Uinta Mts., Aug. 16, 1940 (D. G. Hall), U. S. Nat. Mus. COLORADO: Science Lodge, near Ward, June 17-19, 1939 (Urless Lanham) and May 9, 1939 (H. G. Rodeck, Urless Lanham), U. Colo.; Lindland, July 27, 1938 (James), Masonville, Sept. 3, 1934, Ward, July 14, 1939 (James), and Grizzly Creek Camp Ground, Jackson County, July 17, 1946 (James), all Colo. A. & M, Coll.; Walden, Pingree Park, and Sloss, all U. Kansas; Cameron Pass, Aug. 23, 1940 (D. G. Hall) U. S. Nat. Mus.

Malloch (1935) and Strickland (1938) have recorded this species from Alberta.

Scopeuma pallidum (Walker)

Scatophaga pallida Walker, 1849, List of specimens of Dipterous insects in the collection of the British Museum. Part iv, p. 981.   Type, Martin Falls, Canada.

This species is probably extralimital. It is of relatively common occurrence in Southeastern Canada and the Northeastern United States, at least as far south as North Carolina. Malloch says it probably occurs chiefly in the mountains.

Scopeuma furcatum (Say)

Pyropa furcata Say, 1823, Jour. Acad. Sci. Philadelphia, 3: 98.   Type from Missouri.
Scatophaga squalida Meigen, 1826, Systematische Beschreibung der bekannten europäischen zweiflügeligen Insekten, vol. 5, p. 252.

Though in recent publications European authors (Collin, Carpenter, Sack) have recognized the above synonymy, they have tended to overlook the fact that *furcata* Say has three years' priority over *squalida* Meigen.

This species, like several others in the genus, is quite variable. Malloch in his table of species, states that "only the fore femora [are] partly fuscous, the mid and hind pairs not darkened on the posterodorsal surfaces." However, in an occasional specimen the mid and hind femora are slightly darkened, though for the most part yellow. The "fuscous" marking of the front femora I should characterize as blackish, though this color is considerably dimmed by the overlying pale pollen. An occasional specimen has the front femora wholly yellow.

Widely distributed throughout the Holarctic region. I have numerous records from BRITISH COLUMBIA, ALBERTA, WASHINGTON, OREGON, CALIFORNIA, IDAHO, MONTANA, WYOMING, UTAH, COLORADO, and NEW MEXICO. It is more common farther northward in its range and at higher elevations, where it may replace *S. stercorarium* as the dominant species.

Scopeuma vittatum (van der Wulp)

Scatophaga vittata van der Wulp, 1897, Biologia Centrali-Americana, Vol. 2, p. 350. Type from Mexico City.

This species is probably extralimital. It is known only from Mexico.

SPECIES ERRONEOUSLY REFERRED TO SCOPEUMA

Pseudopogonota aldrichii Malloch

Pseudopogonota aldrichii Malloch, 1920, Proc. Ent. Soc. Washington, 22: 35.
Scatophaga palpalis Malloch, 1931, Ann. Mag. Nat. Hist. (10)8: 443 (new synonymy).

The above synonymy seems virtually certain. Malloch uses the "spoon-shaped" palpi to distinguish *Pseudopogonota* from *Scatophaga*, but in his description of *S. palpalis*, he used this same character ("palpi . . . very distinctly widened apically") to separate his species from *suilla*. *P. aldrichii* was described from both males and females; it is odd that Malloch failed to recognize the female when he described *S. palpalis*. The males of *P. alrichii* are easily recognizable by their genitalia and associated structures; this easily explains why the males of *S. palpalis*, as such, have never been recorded.

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UTILIZATION OF FOOD BY SINEA DIADEMA (FABR.)

(Reduviidae, Hemiptera)[1]

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INTRODUCTION

During the past ten years I have published a series of articles on several bionomic features of two predatory entomophagous Hemiptera, *Sinea diadema* and the phymatid, *Phymata pennsylvanica americana* Melin. A list of these papers is appended for the convenience of interested persons. Among the more recent of these are three that pertain to (a) weight patterns a·ld (b) variability in the duration of the insects. In the course of the work on these two problems, there accumulated a large body of data which now prove to bear also on the utilization of food by the nymphal instars of the above predators. The data relative to *Sinea* are better suited to this question than are those from *Phymata*, and for this reason the present article deals exclusively with *Sinea*. The reader will recognize that the plan of the project on weights and instars did not envisage the results on food-use presented below, and that these are therefore in the nature of by-products. The procedure might have been better designed than it was, had utilization of food been among the original objectives of the undertaking. For example, the diets administered to the several series of experimental bugs were not evenly graduated as to amount, hence the results do not lend themselves to expression in the form of a curve. Yet the data are, I believe, of such significance with reference to insect nutrition as to warrant this publication.

The materials below relate to two features pertinent to research on insect nutrition; first, description of a method of calculating the approximate weight of the food utilized by a predatory insect equipped with fore legs for seizing prey and mouthparts for removing liquids or liquified solids from the prey, leaving the empty chitinous cuticle to be discarded; and second, analysis of some data obtained from *S. diadema* by this method.

METHOD OF DETERMINING THE WEIGHT OF FOOD UTILIZED

Investigators contemplating a study on the quantity of food used by a sucking predator would probably first consider the method whereby the prey is weighed immediately before it is offered to the predator, and again at once after the indigestible chitinous remains of the prey are discarded, the difference between the two weights being the bulk of substance ingested. However, application of this direct method would promptly show it is impractical for the following reasons: (1)

The sucking predator must be supplied throughout its nymphal life of several weeks with prey of a size from which all the digestible, non-chitinous contents may be removed in one continuous feeding operation; (2) the predator utilizes large numbers of such prey individuals while growing up; (3) it cannot be relied on to feed at once when the prey is placed in the cage, with the consequence that the latter loses significant weight from activity and lack of food, and (4) this direct procedure requires alert attention from a group of observers every moment of the nymphal life in order to secure accurate weights of the prey at once preceding and following the feeding of the individual predators employed in the experiment. In short, the direct approach to the problem of nutrition wherein a sucking predator is concerned is obviously not feasible.

For the above reasons, the indirect method, described below, is more desirable for approximating the amount of food which *S. diadema* may ingest. The prey employed in securing such results consisted exclusively of adult flies of *Drosophila melanogaster* (L.). While the method gave fair indications of the quantity of food withdrawn by nymphs of the third and fifth instars, and less precise indications for the first and second, it proved a relatively satisfactory measure for the fourth instar for the reasons that nymphs of the latter stage readily capture the *Drosophila* and thus secure that quantity of food necessary for approximately optimal growth, and they have the capacity to withdraw all the ingestible or liquefiable substance from the flies secured, leaving them light and transparent. By their light weight and transparency, the discarded flies may be known to have been emptied of their digestible contents. As a consequence of these reasons, I shall emphasize the data for the fourth instar. While therefore compelled to employ estimates rather freely in calculating the quantity of food ingested by the first two instars, this necessity incurs no serious error because the amount of food utilized by them constitutes a small part of the total required in the entire nymphal life. The actual weights are employed where the third, fourth and fifth instars are concerned.

The method of calculating the amount of food used by any individual, either during any one stadium or in the entire nymphal life, employs a single value, namely the average amount, by weight, of ingestible substance contained in individual adults of *D. melanogaster*. The procedure in obtaining this value was (1) to weigh 4649 normal living flies in lots of 10 to several hundred each, these being inactivated, for the purpose of weighing, by refrigeration at once upon removal from the rearing tubes; (2) to weigh more than 9000 flies from which all or most of the ingestible liquefiable substance was removed by *Sinea*, such discarded emptied flies being handled in numerical lots of sizes that permitted accurate weights, and as they become available daily from the cages housing the predator. The actual average weight of single flies discarded by *Sinea* was 0.000067043 gram, and the average weight of the single whole inactivated living flies was 0.000831404 gram. The difference between these figures is 0.000764361 gram, which is taken here to be the average quantity of substance removed by suction from individual *Drosophila*. In the course of securing the data, each individual of *Sinea* was kept by itself in a shell vial; and the number

of flies utilized by each bug from day to day was recorded. The number of discarded cuticles was multiplied by the value 0.0007643 in order to obtain the approximate weight of food ingested by an individual nymph of *Sinea* either in any one of the five instars, or in the entire nymphal life. For the sake of making the weights derived by this method more easily comprehended, they are converted into milligrams below.

TABULATED DATA AND METHOD OF CALCULATION

It should be understood that some of the individual *Sinea* in the experimental series failed to complete their nymphal development either

TABLE I

RELATION BETWEEN THE AMOUNT OF FOOD INGESTED AND THE AMOUNT ASSIMILATED BY NYMPHS DURING THE FOURTH INSTAR

AMOUNT INGESTED PER NYMPH	NYMPHS FED	FLIES CONSUMED PER NYMPH	NET GAIN IN WEIGHT	AMOUNT ASSIMILATED
Milligrams	*Number*	*Number*	*Milligrams*	*Percent*
MALES				
0.0– 9.9	4	10–12	2.3– 3.3	25–43
10.0–19.9	2	14–20	2.9– 4.3	27–28
20.0–29.9	6	27–39	4.0– 7.8	20–27
30.0–39.9	11	42–52	7.0– 9.5	19–29
40.0–49.9	12	53–65	7.9–10.8	18–25
60.0–69.9	2	79–83	8.0–10.5	13–16
FEMALES				
0.0– 9.9	1	13	4.0	40
20.0–29.9	3	27–31	5.3– 7.4	22–36
30.0–39.9	9	44–52	5.9–10.2	17–28
40.0–49.9	9	53–65	8.4–13.1	19–28
50.0–59.9	3	66–74	8.6–11.8	15–23

because of accidents in handling, or more frequently because of starvation. Considered below are only those individuals which did survive the dietaries and became adults. It will be noted also that the records for the two sexes are tabulated separately; this is done for the reason that females usually feed more voraciously and ingest a larger bulk of food than the males. Table I contains data that relate to the fourth instar of the males and females, respectively, while Table II pertains to the sum of the five instars, *i.e.* the whole nymphal life. The records are tabulated in the order of the milligrams of food ingested by the several nymphs, and classified or grouped on the basis of quantitatively similar diets utilized (first column).

While the rather extreme range in number of flies used by the feeding bugs is largely the result of my intentional regulation of the amount of the food administered, it probably reflects also some inherent

differences in the feeding proclivities of the individuals. The tables further present data pertinent to (2) the number of nymphs forming each group, (3) the number of *Drosophila* whose digestible contents were withdrawn by the nymphs, (4) the net gain in weight achieved by each group of nymphs, and (5) the percent of the ingested substance that was assimilated as contrasted with the percent eliminated as feces,

TABLE II

AMOUNT INGESTED PER NYMPH	NYMPHS FED	FLIES CONSUMED PER NYMPH	NET GAIN IN WEIGHT	AMOUNT ASSIMILATED
Milligrams	*Number*	*Number*	*Milligrams*	*Percent*
MALES				
30.0- 39.9	1	49	14.0	38
40.0- 49.9	4	54- 64	9.1-17.7	22-36
50.0- 59.9	3	67- 76	12.6-14.5	22-28
60.0- 69.9	3	81- 89	14.1-15.4	22-23
70.0- 79.9	1	95	17.2	24
110.0-119.9	3	145-155	22.9-30.5	19-28
120.0-129.9	5	161-170	20.7-33.6	16-27
130.0-139.9	6	173-182	21.5-31.5	17-24
140.0-149.9	5	186-193	28.4-31.1	20-22
150.0-159.9	3	197-204	31.1-37.8	21-24
160.0-169.9	3	211-219	31.4-36.0	18-22
170.0-179.9	2	233-235	33.7-38.3	19-21
180.0-189.9	1	239	35.8	21
190.0-199.9	1	260	35.6	18
210.0-219.9	1	284	36.8	17
FEMALES				
40.0-49.9	1	61	17.0	36
60.0-69.9	1	83	16.0	25
80.0-89.9	1	106	18.1	22
120.0-129.9	2	161-164	27.7-29.3	23
130.0-139.9	2	177-181	41.1-43.6	30-32
140.0-149.9	1	189	36.3	25
150.0-159.9	6	197-207	38.0-41.4	25-27
160.0-169.9	2	211-213	38.5-38.8	19-24
170.0-179.9	1	226	42.0	24
220.0-229.9	1	293	38.9	17.4
230.0-239.9	1	305	46.9	20.1

gases and exuviae. The net gain was obtained by subtracting the weight of the individual on the first day from its weight on the last day of any instar, or the total nymphal life. The percents of material (1) converted into bodily substance and (2) eliminated as wastes were then calculated by dividing the weight of the ingested matter into the net weight gained during the instar or total nymphal life, and multiplying the result by 100.

DISCUSSION

Following are the principal results obtained by the above-described method of study with reference to the utilization of food by *Sinea diadema*.

The amount, by weight, of food adequate to bring individuals through the fourth instar varied, in the series of males, from 7.6 to 63.4 mg., and in the series of females from 9.9 to 68.7 mg. The weight of food utilized by individuals during the entire nymphal life of five instars ranged, in the series of males, from 37.4 to 217.1 mg., and, in the series of females, from 46.6 to 233.1 mg. In terms of numbers of adult *Drosophila*, the male individuals imbibed the digestible contents of 10 to 83 flies, and the females 13 to 90 flies while undergoing the fourth instar; and growth through the whole nymphal life required from 49 to 284 flies, and from 61 to 305 flies, in the males and females, respectively. The extreme ranges of variability with reference to the quantity of food utilized in the four cases cited are in the ratio of 8.0, 7.0, 5.8 and 5.0 to 1, respectively. The resulting adults varied likewise with reference to weight, vigor, length of life and reproductive capacity, the values of these functions being somewhat directly proportionate to the amount of the diet allowed as indicated in the tables. The females allowed the smaller numbers of flies produced and laid no eggs, while those fed at an approximately optimal rate laid eggs of normal size, color and form, and in numbers adequate to promulgate the species, although not to the maximum extent. Specifically, a female that ingested 222.4 mg. during its nymphal and adult lives, produced only one egg, obtained by postmortem dissection; whereas the female that consumed 370.6 mg., as nymph and adult, laid 39 eggs. Amounts less than 222 mg. were insufficient for the genesis of eggs.

A second feature of note that was revealed in this study is indicated in the fourth and fifth columns of the tables. It pertains to the relation between the amount of food ingested and the percent of the food that was assimilated from the digestive tract into the blood and converted into more or less permanent body substance. Examination of these data show that those *Sinea* which received the smallest amounts of food by weight, both in the fourth instar alone and in the entire nymphal life, made the most efficient use of the material ingested. Comparison of the data from top to bottom in the two columns reveals that the percent of food assimilated gradually decreases as the amount of the diet is increased. Specifically, the male that developed to adult on the least bulk of food, *i.e.* 37.4 mg., or 49 flies, assimilated 37.65 percent of the material ingested, while expending 62.35 percent as wastes. By contrast, the well fed male that developed on 217.1 mg. of food, or 284 flies, assimilated only 16.95 percent, while eliminating 83.05 percent. In general, the individuals falling between the two extremes cited, assimilated less and less while expending more and more of the ingested substance as wastes. However, the rate of growth, as indicated by the data on net gain in weight, increased with each enlargement of the diet, although the rate of acceleration in growth appears to decline somewhat as the diet approached the maximum in amounts allowed.

The above data indicate the principle that assimilation is inversely

proportional to the amount of food ingested, while elimination, particularly of fecal wastes, is directly proportional to the quantity of the food ingested. As a possible explanation of this reversal in effectiveness in the use of food, I venture the thought that this phenomen is, at least in part, the result of variation in mechanical pressure of food in the alimentary tract. The smaller bulk ingested by individuals that are allowed a quantitatively low diet, passes slowly through the tract and is thus exposed a longer time to the absorptive surfaces of the midgut, with the result that a larger percent of the material becomes assimilated and a smaller part remains to be eliminated as feces. On the other hand, the larger to large bulks of food ingested through more frequent and more voluminous feeding by individuals allowed all the food they were able to take, enable the gut walls to force the material through the tract in a shorter time, with the consequence that relatively less of the nutrient elements can be assimilated or utilized.

CRITICISM OF THE METHOD

This indirect method of determining the amount and disposition of the food used by *Sinea* obviously has its shortcomings. In reflecting upon my experience with it, I can now make suggestions that may reduce the amount of error incurred. First, the predatory bugs, weighed individually and daily in my work, might be weighed hourly; this would be desirable especially during the molting phase of each instar. Second, the average weight of a living *Drosophila* could perhaps be determined more precisely if the flies were inactivated, for the purpose of facilitating their weighing, by means of a gas, because refrigeration probably causes condensation of moisture on the cold bodies after transfer to the balance and thus prejudices the results. Third, all flies discarded by the predator should be examined with a binocular in order to estimate more accurately the amount of ingestible substance that may have been left in them. However, in the large majority of cases, practically 100 percent of the substance is removed. Fourth, there was doubtlessly some disparity between the theoretical weight of the substance removable from an individual *Drosophila* and the weight of the substance actually contained in flies provided for the predator: for instance, while one individual *Sinea* probably chanced to receive mostly smaller flies during the nymphal life, another chanced to receive larger flies, with the result that some bugs were possibly smaller or larger, and yet are recorded in the tables as having utilized about equal numbers of flies. This shortcoming might be minimized if the experimenter would use only *Drosophila* produced during any one age period of the culture, *e.g.* the somewhat uniformly larger flies developing in the first days the culture is productive. This would require a larger number of cultures, but the number might be reduced if fewer bugs were included in the experiment at any one time. Were this suggestion adopted, a new average weight per fly would need to be established, based on the larger flies only, not on the entire yield of a set of cultures.

SUMMARY

A method of determining the approximate weight of food ingested

and assimilated by a predatory sucking entomophagous bug, *Sinea diadema*, is described.

Two general results obtained by this method are stated. First, the amount of food required to grow adults varied extremely, males having been produced on quantities ranging from 37.4 to 217.1 mg. of substance taken from adult *Drosophila melanogaster*, and females on amounts of 46.6 to 233.1 mg. The adults thus reared varied correspondingly in respect to their weight, rate of growth, vigor and reproductive capacity.

Second, individuals given a quantitatively small diet assimilated a higher percent of the food ingested than did individuals allowed a near-optimal diet. This inverse ratio of assimilation to amount of food ingested possibly results in part from differences in peristaltic action on small as compared with large bulks of food, the larger bulks passing through the tract in less time, with the consequent assimilation of a relatively smaller percent of the ingested substance.

Several suggestions are offered to improve the accuracy of results from the use of this method, should other experimenters desire to employ it in research on the utilization of food by sucking predatory bugs.

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THE CHANGES IN THE THIAMINE, RIBOFLAVIN, NIACIN AND PANTOTHENIC ACID CONTENT IN THE FOOD OF FEMALE HONEYBEES DURING GROWTH WITH A NOTE ON THE VITAMIN K ACTIVITY OF ROYAL JELLY AND BEEBREAD[1]

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The term "royal jelly" refers to the product formed and secreted by the pharyngeal glands of the nurse bees for the nourishment of the queen larvae. Larvae which are to become the sexually underdeveloped female worker bees receive during the first two to three days of their development the "larval food" similar to that given the queen larvae. Afterwards they are believed to be supplied with the "larval food" which is poorer in nitrogenous materials and lacks a factor or factors necessary for the production of queens. Recent investigations (Haydak, 1943) showed, however, that the food of older worker larvae does not differ appreciably in its protein content from the food of older queen larvae, but is considerably lower in the fat and mineral contents. The major purpose of this study was to determine whether there are any differences in the concentration of certain of the B vitamins in the food supplied to the queen and worker larvae during the period of their growth.

The vitamin content of royal jelly has been determined by several workers. A review of the earlier studies has been given in previous papers (Haydak and Palmer, 1938, 1940, 1942). Recently Pearson and Burgin (1941) found royal jelly to be the richest source of pantothenic acid, containing 183 micrograms and 511 micrograms of this vitamin per gram of fresh and dry matter, respectively. Cheldelin and Williams (1942) made quantitative determinations of most of the known B vitamins in royal jelly. Their results are presented in Table I.

The results of the B vitamins determination in royal jelly made by Kitzes, Schuette and Elvehjem (1943) are in the same range with those of Cheldelin and Williams, the values being 320, 28, 111, 18, 10, 4.1 and 0.5 micrograms per gram for pantothenic acid, riboflavin, niacin, thiamine, pyridoxin, biotin and folic acid respectively. Kocher (1942), using the *Phycomycetes* test found 4.5–5.2 micrograms of thiamine per gram of royal jelly.

During the swarming season of 1942, royal jelly was collected from the cells containing queen larvae. The food was removed from the cells and kept separately, according to the age of the larvae. In this way the secretion was taken from open queen cells containing 1-, 2-, 3-, 4-, 5-day old larvae and from sealed cells with 6 to 7-day old larvae. It was found difficult to secure enough material for each of the consecutive days of this period in the case of worker larvae because of the minute quantities deposited in their cells. Therefore the food from the cells containing worker larvae from hatching to two days of age was combined, and the food from the cells containing larvae three to five days old also formed a single sample. The methods of analysis used were: for thiamine, that of Hennessy and Ceresedo (1939); for riboflavin the method of Snell and Strong (1939); for pantothenic acid that of Strong, Feeney and Earle (1941), and for niacin the method of Melnick and Field (1940). The antihemorrhagic activity of combined samples of royal jelly was determined by a slightly modified method of Almquist (1941).

TABLE I

B VITAMINS OF ROYAL JELLY (MICROGRAMS PER GRAM)

(Cheldelin & Williams)

	Thiamine	Ribo-flavin	Pyridoxin	Niacin	Panto-thenic acid	Biotin	Inositol	Folic acid
Fresh............	6.6	8.2	2.4	59	89	1.7	100	0.20
Dry..............	21.0	26.0	7.7	190	290	5.4	310	0.62
Max.-Min. (fresh)..	7.4–5.6	10.0–6.6	2.5–2.2	47–73	110–65	1.8–1.6	150–78	0.22–0.16

From the results of the analysis presented in Table II it is evident that there was not much change in the thiamine content of both fresh royal jelly and larval food given to the larvae during their growth period. However, when we compare the results on the dry basis then there was a slight variation in the food of the queen larvae and approximately a 30% drop in the content of thiamine in the food given to older worker larvae.

The thiamine content given in Table II is considerably below the values given in the literature. Haydak and Palmer (1940), using the rat assay method, found the thiamine content of royal jelly of 1939 to be equal to 3.1 micrograms/gm. of fresh and 9.1 micrograms/gm. of dry matter. Later investigations by the same authors (1942), using the microchemical method, showed the thiamine content of fresh royal jelly collected in 1940 to be 2.9 micrograms/gm. and for that collected in 1941 to be 1.5 micrograms/gm. Analysis by Haydak, using the microchemical method, of the fresh royal jelly collected in 1943, showed the values of 6.4, 3.9, 4.6, 4.7, 4.6 micrograms/gm. for the food taken from the cells containing 1-, 2-, 3-, 4-, and 5-day old queen larvae, respectively. Cheldelin and Williams (1942) and Kitzes and co-workers (1943) gave still higher values. It appears that the thiamine content

of royal jelly is quite variable, depending probably on the composition of pollen consumed by the nurse bees.

Determinations of the thiamine content of the fresh larval food collected in 1947, made at the University of Minnesota Laboratory of Physiological Hygiene, showed average values of 3.2 micrograms/gm. in the food of 1- to 2-day old worker larvae and 3.3 micrograms/gm. in that of 3- to 10-day old.

There was a decrease in the riboflavin content in the food given to the older queen and worker larvae. The fresh food of 2-day old queen

TABLE II

VITAMIN CONTENT OF LARVAL FOOD (MICROGRAMS PER GRAM)

Age of Larvae	Moisture	Dry Matter	FRESH BASIS				DRY BASIS			
			Thia-mine	Ribo-flavin	Niacin	Panto-thenic Acid	Thia-mine	Ribo-flavin	Niacin	Panto-thenic Acid
Queen. *Royal Jelly*										
1....	65.37	34.63	1.3	8.3	149	200	3.6	24.0	430	578
2.....	69.17	30.83	1.2	6.1	101	180	4.0	19.8	327	583
3............ ..	69.88	30.12	1.2	5.9	91	194	4.0	19.7	302	644
4..	69.70	30.30	1.2	5.6	91	199	3.9	18.6	300	657
5..............	67.58	32.42	1.2	5.3	99	172	3.6	19.6	305	530
Sealed.........	68.32	31.68	1.2	7.0	98	160	3.8	22.1	310	506
Royal Jelly (combined results)										
1–2............	66.77	32.73	1.2	7.2	125	190	3.8	21.9	379	581
3–5....	69.05	30.95	1.2	6.0	94	188	3.9	19.3	302	610
Worker. *Larval food*										
1–2........	73.51	26.49	1.3	11.7	100	147	4.9	44.1	377	554
3–5...........	64.90	35.10	1.2	10.8	52	20	3.4	30.8	148	57
Pollen (Vivino and Palmer, 1944)			9.3	18.5	200	27.6	11.8	23.5	254	35.1
Worker larvae (1- to 3-day old) (Haydak & Vivino, 1943)			4.6	32.2	77.2	180.2	29.9	161.3	393.6	916.1

larvae had 26% less riboflavin than that of 1-day old. The content of riboflavin gradually diminished afterwards. On the dry matter basis the decrease was 17.5% on the second day.

An 8% drop in the riboflavin content of food given to older worker larvae was also observed. On the dry matter basis this drop is much more significant, amounting to 30% of that in the food of 1- to 2-day old larvae.

The decrease in the niacin content of royal jelly given to 2-day old queen larvae was 33% on the fresh and 24% on the dry matter basis. A considerably larger drop was observed in the niacin content of the

food of older worker larvae amounting to 48% on the basis of fresh and 61% on the basis of dry matter.

There was a slight decrease in the pantothenic acid content in the fresh food of older queen larvae. On the dry matter basis, however, there was a gradual increase in the panthothenic acid content of the food of older queen larvae up to the fourth day of their development, amounting to 14%. Then it dropped considerably (19%).

The pantothenic acid content of the food of older worker larvae abruptly diminished to a very great extent in comparison with the food of younger larvae, amounting to 86% and 90% for the fresh and dry weight of the food respectively.

In order to make a better comparison between the changes in the vitamin content of the food given to the queen and worker larvae during their development the results of analysis of the food of the queen larvae were grouped in the same way as in the case of worker larvae. Because of a considerable difference in the moisture content and a different trend in moisture changes (which increased in the food of older queen larvae by 3% and decreased considerably in the food of older worker larvae by 11.7%,) only a comparison on the dry matter basis is here made.

In spite of this grouping, it is somewhat difficult to compare the food of the queen and worker larvae of the same age, because the former were supplied with an overabundance of food which was carried over from one day to another, while worker larvae received considerably smaller daily doses and in the later part of their larval life the feeding was of a progressive type, the food being given as needed. Nevertheless, such a comparison is of interest. There is a slight increase in the thiamine and pantothenic acid content (by 5%) of the food of older queen larvae and a drop in the content of riboflavin (by 12%) and niacin (by 20%). However, as it has been pointed previously, there was a very sharp drop in the content of all vitamins investigated in the case of worker larvae, being equal to 30% in the content of thiamine and riboflavin and an especially large drop in the niacin (61%) and pantothenic acid (90%) contents.

Apparently the pharyngeal glands of the nurse bees do not have an ability to concentrate thiamine, riboflavin and niacin which they ingest with pollen, the latter having 9.3, 18.5, and 200 micrograms per gram of fresh matter respectively (Vivino and Palmer, 1944). On the other hand, the ability of the glands to concentrate pantothenic acid is amazing, because the pantothenic acid content of the dry matter of royal jelly is 16 to 19 times greater than that of pollen.

Young worker larvae also have an ability to concentrate thiamine, riboflavin and pantothenic acid, those values being 4.6, 32.2, and 180 micrograms per gram of fresh matter of their bodies and 29.9, 161.3 and 916.1 micrograms per gram of the dry matter respectively (Haydak and Vivino, 1943). These values are considerably large than those found for the larval food of workers.

It is evident from Table II that the concentration of riboflavin, niacin and especially pantothenic acid is very significantly lower in the food of older worker larvae. One is hardly justified in assuming that the nurse bees deliberately change the composition of their glandular secretion when feeding older larvae. However, Kohler (1922) and

Nelson and Sturtevant (1924) observed that the nurse bees add pollen to the food of older larvae.   Planta (1888), to the contrary, found no pollen in the food of either younger or the older worker larvae.   Microscopical examinations of our samples in 1942 showed an average of 6 grains of pollen and in 1948 only occasional grains of pollen per unit of a field of vision for the food of 1- to 2-day old larvae and an average of 11 and 9 grains for the same surface of the food of older larvae for years 1942 and 1948 respectively.   The color and consistency of the food of both groups of larvae was also different.   While the food of the younger larvae was milky white, showing a large number of white amorphous bodies present under microscope, the food of 3- to 5-day old worker larvae was grayish with a very few amorphous bodies present.

It is not likely that the presence of pollen (which is much lower in the pantothenic acid content than the food of younger larvae) in the food of older larvae is the cause of the lower pantothenic acid content of this food.   If this were the case, then the thiamine, riboflavin and niacin content of the food of older larvae should have increased, because the amount of these vitamins in pollen is greater than that in the fresh food of younger larvae.   Of course, the vitamin content of pollens varies and the nurse bees may consume beebread of various origin and age present in the hive.   However, the drop in the vitamin content of the food of older larvae is a normal phenomenon, because a later (1948) check on the vitamin content of the food of younger and older worker larvae showed that the riboflavin, niacin and pantothenic acid content of the fresh food has dropped from 11.7, 81.7, and 128.6 micrograms per gram in the fresh food of 1- to 2-day old larvae to 10.8, 45.3 and 19.5 micrograms per gram in the food of older larvae respectively.

According to Rösch (1925), younger larvae, under normal conditions, are fed by bees 6 to 10 days old, which have reached their highest development (Haydak, 1934), while the younger, 3- to 5-day old bees, supply the food to the older larvae.   It seems probable that the change in the concentration of the vitamins in the food of older larvae is due to the fact that the pharyngeal glands of the young bees are not sufficiently developed to secrete the larval food having the same vitamin content as that secreted by the older nurse bees.   It is also conceivable that because the younger bees continue to grow up to the fifth day of their lives, the requirement for vitamins, especially those associated with intracellular respiratory enzymes, is so great that only the excess amount of the vitamins is secreted with larval food.   It is also quite possible that these young nurse bees, while ingesting large amounts of pollen, may contaminate the larval food with the pollen grains while feeding the larvae.   That an admixture of pollen with the food of larvae is accidental and not essential for the production of workers is apparent from the fact that adult bees can produce workers when supplied only with sugar solution, utilizing the stores of their own bodies for the synthesis of the larval food (Haydak, 1935).

To what an extent this drop in the vitamin content of the food of older worker larvae contributes to the underdevelopment of the older worker larvae is difficult to say without a further investigation of the requirements of the bee larvae for these vitamins.   However, since the B group vitamins are necessary for growth, then their deficiency will bring the retardation in the development of a growing organism.

The results of these investigations show that there is not much variation in the vitamin content of the food of the queen larvae supplied during their growth. Recent observations by Taranov and Ivanova (1946) and of Taranov (1947) give a clue to the explanation of this phenomenon. In a colony preparing to swarm there is an excess of unemployed nurse bees. The swarm cells are started because of the discrepancy between the egg laying activity of the queen and the amount of the larval food produced. The latter, especially in the strong colonies, cannot be utilized as food either for the brood or the queen, and consequently the bees force the queen to deposit eggs in the queen cups. As soon as the queen larvae hatch, the unemployed nurse bees can lavishly supply the larvae with the food. In such a case, of course, a greater uniformity in the composition of the food could be expected, which actually exists as our investigations demonstrated.

Bioassays, using vitamin K deficient chicks, showed that royal jelly did not manifest any antihemorrhagic activity when fed for four days at the rate of one gram daily in water suspension with a supplement of ethyl laurate. The fatty acid ester was supplied in order to assure the presence of a fatty carrier in the intestines of the chicks.

Samples of beebread (pollen stored in the cells of combs by the bees) from 1938, 1939 and 1940 collections were also investigated for their antihemorrhagic activity. The prothrombin time was 2 min. 48 sec., 2 min. 51 sec., and 3 min. 2 sec., respectively, when 1 gm. of each beebread sample was supplied daily for four days during the curative period to vitamin K depleted chicks. This corresponds quite closely with the average prothrombin time of 2 min. 57 sec. for positive controls which received one microgram of synthetic vitamin K (2-methyl-1, 4-naphtoquinone in ethyl laurate) daily during the same period. The prothrombin time of the negative controls was 25 minutes.

It is of interest to note that mixed pollens brought to the hive by bees possess no vitamin K activity (Vivino and Palmer, 1944). Probably the bacteria which are instrumental in fermentation of beebread (pollen deposited in the cells of combs) synthesize vitamin K.

SUMMARY

The daily changes in the concentration of thiamine, riboflavin, niacin and pantothenic acid in royal jelly have been investigated. The thiamine content remained fairly constant, although values obtained by several investigators varied considerably. The riboflavin, niacin and pantothenic acid contents diminished as the age of queen larvae advanced, the sharpest drop being between the first and second day of larval life. The pantothenic acid content in the dry matter of royal jelly increased up to the fourth day of larval life, then it dropped considerably.

The thiamine content of the fresh food of worker larvae remained practically unchanged during their development. However, on the dry matter basis, there was a drop of 30% in the content of this vitamin in the food of older larvae. The concentrations of riboflavin, niacin and pantothenic acid in the food of 3- to 5-day old worker larvae were significantly diminished as compared with the food of 1- to 2-day old larvae.

It is suggested that the differences in the vitamin concentration of the food of older worker larvae as compared with that of the younger larvae are due to the fact that the incompletely developed pharyngeal glands of the young nurse bees feeding the older larvae do not produce the larval food of the same vitamin content as that secreted by the older nurse bees feeding the younger larvae.

Royal jelly did not exhibit any antihemorrhagic activity. One gram of beebread showed a vitamin K potency equivalent to one microgram of 2-methyl-1, 4 naphtoquinone.

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A NEW NAUCORID GENUS AND SPECIES
FROM NEVADA
(Hemiptera)[1]

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Family Naucoridae

Subfamily Limnocorinae

Usingerinini tribus novus

Usingerina genus novum

Generic characteristics.—Head narrowly and briefly foveate on either side near anterior margins; antennae very short, not reaching inner anterior angles of eyes. *Pronotum* very short and broad, four times broader than long, posterolateral angles prominent, expanded and narrowly rounded. *Scutellum* with lateral margins elevated, sinuate at middle, the disc feebly depressed. *Hemelytra* possessing the most obviously distinct characteristics of the genus: claval suture wanting; claval and corial veins thickened and elevated; embolium prolonged into a single, sharp, long, curved spine at its posterolateral angle; membrane thickened, greatly reduced, merely a thin inverted "V," terminal width distinctly less than 50% of length. *Hindwings* greatly reduced, usually extending just slightly caudad of middle of second visible abdominal segment. *Abdominal segmentation* obsolescent in mid-dorsum.

Genotype.—Usingerina moapensis sp. nov.

Usingerina moapensis species nova

*General appearance.—*Broadly oval in outline, with a marked tendency toward lateral expansion of pronotum, embolia and abdomen; darker in color posteriorly, the mottling fading to light yellow anteriorly; size small, 5.25–6.0 mm. long and 4.5–5.0 mm. wide (at widest part of abdomen, excluding embolia).

*Head.—*White to whitish-yellow, with a variable development of brown dotting and suffusion; the most clearly defined pattern is one consisting of several series of brown punctures surrounded by brownish suffusion, each series forming a bar. One such strong bar lies laterally paralleling each inner eye margin; a medially interrupted bar, curving slightly caudad, occupies the posterior edge of head; two pairs of short, longitudinal bars occupy the center of the head, the innermost pair consisting of a strong series of punctures, the outermost more in the

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nature of brownish suffusions with a tendency to spread out anteriorly; random dotting occurs in area between posterior interrupted bar and caudal ends of median central bars; surface generally polished and shiny, with punctures as indicated above. When oriented so that dorsal plane of head is perpendicular to line-of-vision (*i. e.*, the greatest amount of dorsum exposed to view), front of head is seen to be markedly protuberant forward; head more protuberant before eyes than behind eyes (see ratios 4 and 5). Anterior margin of head bearing a thin, shallow, faint foveate line near each eye. Eyes reddish-black; outer and posterior margins curving imperceptibly into each other; outer and anterior margins subangulate at junction; viewed posteriorly, eyes markedly protuberant above general head surface. Entire head, including eyes, characteristically deeply set into anterior pronotal margin, anterolateral eye margin nearly forming a continuous, smooth contour with anterolateral pronotal angle. Mouthparts darkening at tip.

Head ratios are

1) total length to width (including eye), 32: 50.
2) anterior distance between eyes to posterior distance, 34: 30.
3) posterior distance between eyes to greatest length of head posterior
   to this line, 30: 4.
4) eye length to width, 26: 11.
5) posterior distance between eyes to greatest length of head anterior
   to a line drawn between anterior gape of eyes, 30: 6.

Pronotum.—Dull, slightly roughened and irregular, with some large and small punctures, and patterned with brown dots and suffusions. Groundcolor whitish with a variable development of dotted patterns, occasionally with a faint rosy suffusion mediocentrally. When best developed, pattern shows an irregular, semitriangular area outlining and coloring the low, broad callus of pronotal disc to each side of the median line. Lateral pronotal expansions may be largely white, or strongly dotted with large, isolated, brown dots; posterior border may be similarly bare or marked. There is usually a broken series of brown dots along the medioanterior pronotal border. Broad "V"-shaped parallel rugosities in anteromedian portion of disc, flanked by the two calli. Lateral edges minutely crenulate, lacking any marginal pilosity. Pronotum strongly expanded laterally, percent of expansion (expressed in terms of straightline distance between anterolateral and posterior angles, and the longest line perpendicular to this baseline between baseline and pronotal lateral edge) between 34 and 35 (whereas in *Limnocoris signoreti*, such expansion is only between 21 and 22%). Posterolateral corners nearly right-angulate with apices rounded, some distance laterally removed from the posterior angles (which latter are weak and hardly apparent as slight sinuosities in the posterior pronotal margin near lateral edges; in *L. signoreti*, the posterolaterals are obsolescent, not evident by virtue of the smoothly curving edge of the pronotum, and the posterior angles proper are very near pronotal edge). Propleura blackish along borders, except posteriorly, yellowish centrally. Prosternal carina prominent anteriorly, topped by two equisized tubercles, best seen in lateral view.

Pronotal ratios are

1) width between anterolateral angles to width between postero-lateral angles, 56: 116.
2) median length to greatest width, 29: 116.
3) width between anterolateral angles to distance between these angles and posterior base line of pronotum, 56: 44.

Scutellum.—Broadly "V"-shaped, largely whitish-yellow with brownish suffusions posteriorly and laterally, and generally with two prominent blackish spots at anterior margin between centrum and lateral angles; surface slightly roughened. Lateral margins elevated, sinuate at middle, disc feebly depressed. In normal position, *i. e.*, approximately on a plane surface with remainder of body, ratio of three sides, anterior and two laterals, respectively, is 52 : 38 : 38.

Hemelytra.—In alcoholic material, transparent enough for brownish abdominal color to show through, the raised, coarse claval and corial veins appearing white by comparison; in dried specimens, entire surface slightly roughened, whitish-crustose, considerable blackish showing through except around and on embolia and along raised veins, which are uninterruptedly whitish. Claval suture wanting. (In *L. signoreti*, the hemelytral veins are not raised, and claval suture is present). Membrane generally lacking white crustosity posteriorly and on left side, better seen in alcoholic than dried material, and as a consequence distinctly blacker. Membrane greatly reduced in size, forming a thin, inverted "V" which is less than 50% (60 : 26) as wide as long (whereas in *L. signoreti*, the well-developed membrane is considerably more than 75% (90 : 80) as wide as long). Embolium quite remarkable, laterally expanded and terminating posterolaterally in a long, sharp, posteriorly curved spine. Hemelytra strongly exposing lateral connexival margins which are slightly darker in color; posterolateral connexival angles non-spinose, each segment fitting tightly to the other, with no overlap or discontinuity of outline. Hemelytra barely attaining abdominal tip.

Venter.—The prothoracic venter has been discussed above. Remainder of thoracic venter rich yellow in alcoholic material, generally distinctly, but only slightly, lighter than abdominal venter. In dried specimens, the fine, dense pilosity of abdomen is quite evident, extending to sternal area and leg bases, remainder of thoracic venter being largely bare. Median carinae three in number, the anterior two foveate, the posterior one a low, inconspicuous ridge. Mesosternal carina the largest, its deep suctorial fovea large, round, lying centrally between fore- and mid-legs, and bordered anteriorly by a small, raised tubercle; metasternal carina smaller, lower, its suctorial fovea shallow and lying just posteriad to insertion of mesolegs; carina of first two visible abdominal segments thin, plate-like, anteriorly widened slightly posteriorly and extending beneath third ventral segment; carinal foveae blackish in contrast to yellow sternal plates.

Legs.—Prolegs with typical globular coxae, incrassate femora, thin, lancetlike tibia-tarsi which rest, when closed, in grooves along femoral surfaces; tibia-tarsi darkening at tip, in contrast to whitish femora and, when closed, not quite attaining proximad end of femora. Meso- and meta-legs similarly whitish with contrasting brown spines and spinules

arranged symmetrically along edges of the box-like femora and tibia
(spines on tibia, spinules on femora). Meta-tibia and -tarsi thickly
furred on inner margins with long, whitish hairs which form a solid
swimming web. Meso- and meta-tarsi two-segmented, tipped with
two large, brownish claws.
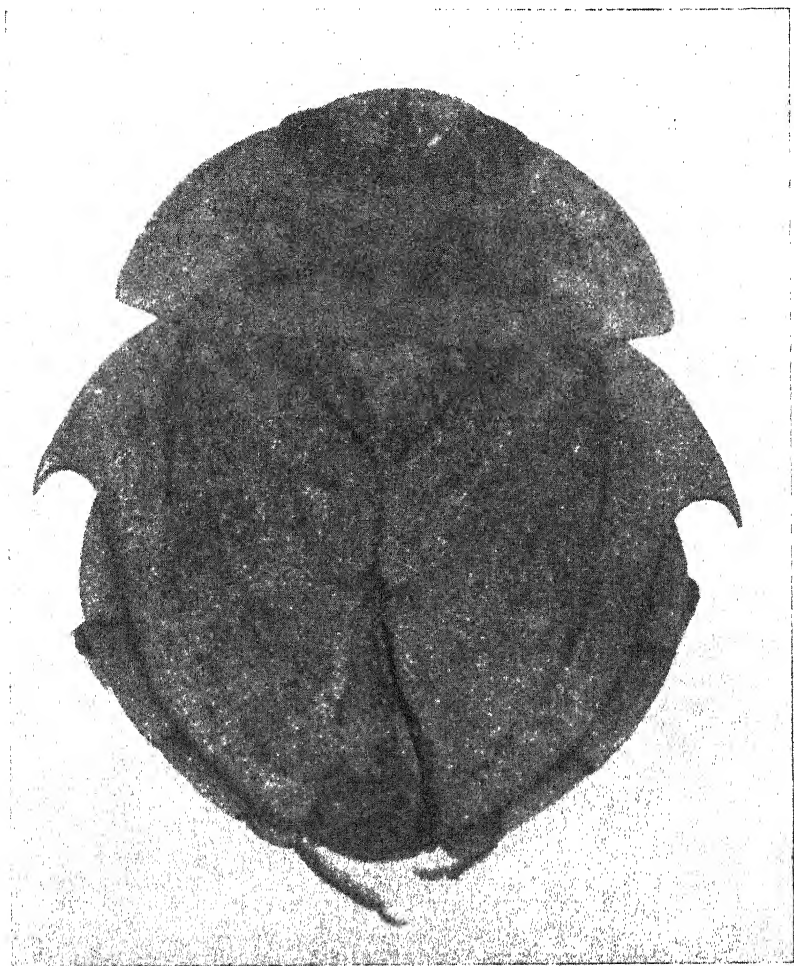
FIG. 1.   *Usingerina moapensis* La Rivers, female allotype.

Type locality data.—NEVADA, Clark County (*Warm Springs* (outlet
streams of Big Pool) 26–27 (xii) 48, el. 1700 ft.–LaR). Known only
from the type locality.
    Disposition of types.—Holotype, allotype and four paratypes in the
California Academy of Sciences (San Francisco); paratypes in the

collections of Dr. Robert L. Usinger (Berkeley, California); Snow Museum, University of Kansas (Lawrence); U. S. National Museum (Washington); American Museum of Natural History (New York City); British Museum (London); Paris Museum (France); and the writer (Reno, Nevada).

Ecologic data.—Since I have already characterized the general aspects of the type locality in a previous paper (reference 5), the following notes will merely be supplementary. *Usingerina moapensis* was found only in swift warm water, varying in temperature from 89° F. to 75° F. (Stations A and B, respectively), the former representing a collecting locality but a few yards downstream from the source pool, the latter a locality some 100 feet farther downstream and a few yards up a small, cooler tributary which came from the Pelocoris marsh (see below). Hydrogen-ion concentrations as determined with a Hellige pocket comparator, gave a pH of 7.3 at Station A, and 7.5 at Station B. At the latter, *U. moapensis* was found with the omnipresent *Ambrysus mormon* Montandon 1909, the latter dominant, whereas at Station A, where *Usingerina* predominated, only an occasional *A. mormon* was present in the ratio of approximately 1 : 20. In this last situation, *A. mormon* was found most commonly in streaming vegetation along the shores and sides, while the gravel bed of the stream was occupied by large numbers of *U. moapensis*. Although *Pelocoris shoshone* La Rivers 1948 was found a few yards away in a marsh drained by the small stream on which Station B was located, it did not seem to occur beyond the marsh, and there were no indications that *Usingerina* and *Pelocoris* occupied the same environment. This is not strange when the habitat preferences of the two are considered. The former is an habitue of gravel-bottomed swift streams, while the latter prefers the overhanging turf banks and shores of slow and still water. That it was not a matter of temperature is shown by the fact that *P. shoshone* was found in water of 83° F. (pH 7.3), well within the range of *U. moapensis*. *Ambrysus* was also absent from the Pelocoris marsh, although *A. mormon* was in dominance in the small drain ditch mentioned above at the foot of the marsh, where the tiny stream fell turbulently down a steep 15-foot slope from the marsh to a small meadow, through which latter it meandered for a few yards before entering the main stream in which Station A was located.

In its bottom preferences, *U. moapensis* greatly resembles another markedly endemic naucorid, *Ambrysus funebris* La Rivers 1948 from Death Valley. Both species avoid stream bottoms where the water is slow enough to allow fine sand to accumulate, or swift enough to sweep gravel away; only in gravel areas of intermediate stream flow is either found, and then in large numbers, several commonly taken in one sweep of the seine.

The only other prominent associated invertebrates found in this small drainage complex at the time of winter collecting were a new species each of the dryopids *Stenelmis* and *Microcylloepus*, the former being found in both Pelocoris marsh and the swift, major streams occupied by *Usingerina*. The small cyprinodont fish *Crenichthys beileyi* (Gilbert) 1893 was the dominant vertebrate common to the

entire system, while the newly described cyprinid *Moapa coriacea* Hubbs & Miller 1948 was absent only from the marsh.

At the present time, it is difficult to place *Usingerina* phylogenetically. It is a characteristic limnocorine by virtue of its ventral foveate carinae, but differs so remarkably from any known *Limnocoris* (the only genus hitherto known in the subfamily) in other features that it warrants tribal separation.

Dr. Robert L. Usinger, to whom I dedicate the genus in appreciation of many past favors and in regard for his outstanding work in the family, was kind enough to compare the animal with type material of *Limnocoris* in the Montandon collection (British Museum), and pointed out (*in litt.*) that while its nearest geographical relative was *Limnocoris signoreti*, *U. moapensis* was structurally unlike any other members of the subfamily of his acquaintance.

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HYDRELLIA (EPHYDRIDAE) AND SOME OTHER ACALYPTRATE DIPTERA REARED FROM POTAMOGETON[1]

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In an earlier paper (Berg, 1949) 32 species of insects intimately associated with plants of the genus *Potamogeton* in Michigan were listed. Species of plants and areas in which they were collected were recorded. The insects, including Diptera of 17 species, were dismissed with a few general remarks concerning aquatic adaptations, modes of hibernation, and injuries inflicted upon host plants. Biology and morphology of immature stages of nine species of Chironomidae reared from *Potamogeton* are discussed in another paper (Berg, 1950). Similar data regarding eight acalyptrate species will be presented here. Parasitic Hymenoptera reared from puparia of *Hydrellia* in this investigation represent nine species, seven of which appear to be new. Publication of data on the biology of these interesting insects will be deferred until they are described and specific names become available.

Larvae of the six species of *Hydrellia* included here seem to be directly related to *Potamogeton* species in three important respects. As leaf- and stem-miners they depend on these plants for food. The plant epidermis which conceals and shelters them apparently affords a considerable degree of protection. Circumstantial evidence indicates that *Hydrellia* larvae normally obtain oxygen from the intercellular gas spaces of these plants. No evidence of nutritive or protective relationships between *Potamogeton* and larvae of the two other acalyptrate flies was observed. It is apparent, however, that *Notiphila loewi* larvae regularly depend on these plants for sufficient oxygen to maintain life, and that specimens of *Hydromyza confluens* less frequently do the same.

I gratefully acknowledge the guidance and substantial assistance of Professor Paul S. Welch, identifications of four species and original descriptions of three others furnished by the late E. T. Cresson, Jr., formerly of The Academy of Natural Sciences of Philadelphia, and identification of *Hydromyza confluens* supplied by F. M. Snyder, of Orlando, Florida.

Hydrellia (Ephydridae)

It appears that the genus *Hydrellia* has been reported from all zoogeographic regions except the Neotropical. Cresson (1932) published taxonomic notes on 32 species from such widely separated regions as Australia, Formosa, South Africa, Europe, and North America, and his subsequent descriptions include two species from Hawaii (Cresson,

1936). Becker (1926) discussed 35 European species and presented a bibliography of papers on the biology and immature stages of some of them. Cresson (1944) gave distributional notes and keys to 35 Nearctic species, and the taxonomy presented by him is followed in this paper.

All *Hydrellia* larvae of known habits are phytophagous. Those of most species mine in leaves and stems of aquatic plants, but others attack terrestrial plants, especially the grasses. Some larvae, such as those of *H. griseola* Fallen (De Ong, 1922, as *H. scapularis* Lowe; Wilke, 1924; Kortung, 1931) and *H. nasturtii* Collin (Marchall, 1903, as *H. ranunculi* Haliday; Collin, 1928; Taylor, 1928; Vayssiére, 1933) mine in the leaves of grains and water cress and sometimes assume economic importance. Hendel (1926), Hering (1935–'37), and Hennig (1943) reviewed the knowledge concerning immature stages of European *Hydrellia*.

The larvae of five European species of *Hydrellia* are known to live on *Potamogeton*. Thienemann (1916) reported *Hydrellia chrysostoma* Meigen from *P. lucens* and *H. nigripes* Meigen from *P. crispus*. Muller (1922) found *H. nigripes* mining in both *P. lucens* and *P. perfoliatus*. Brocher (1910) reared *H. modesta* Loew from an unspecified species of *Potamogeton*, and Thienemann (1916) found what was possibly the same species mining in the leaves of *P. natans*. Hering (1930) described *H. potamogeti* from material "aus Minen an Potamogeton erzogen," and (1935–'37) also reported *H. chrysostoma*, *H. nigripes*, and *H. fascitibia* v. Roser from *Potamogeton*. Wesenberg-Lund (1943) reported *H. modesta* from *P. natans*.

Very little has been published concerning immature stages of North American *Hydrellia*. Malloch (1915) figured the puparium and posterior part of the larva of *H. griseola* var. *scapularis* Lowe, and reported that the larva mines in *Panicum*. From a single specimen, Johannsen (1935) described the puparium of *H. griseola* var. *hypoleuca* Loew, but was unable either to distinguish it from that of variety *scapularis* or to name the food plant. Johannsen also described briefly a puparium believed to be that of *H. cruralis* Coquillet, and illustrated parts of the larva of *Hydrellia* sp. None of the scattered references to the occurrence of Nearctic *Hydrellia* larvae in *Potamogeton* (Moore, 1915; Frost, 1924; Cresson, 1934, 1944; Johannsen, 1935) specifically identifies both the fly and its food plant.

In the present investigation more than 800 specimens of *Hydrellia* were reared from larvae and pupae found in *Potamogeton*. These flies represent six species, of which *H. cruralis* Coquillet, *H. pulla* Cresson, and *H. caliginosa* Cresson were known before this study was undertaken, and *H. bergi* Cresson, *H. ascita* Cresson, and *H. luctuosa* Cresson have been described since from specimens reared in the pursuit of this research.

Eggs which were observed, those of *H. bergi*, *H. cruralis*, and *H. pulla*, are elongate, cylindrical, measuring approximately 0.5x0.15 mm. All have irregular longitudinal furrows in the chorion, and each possesses a bell-shaped projection bearing the micropyle near one end.

Mature *Hydrellia* larvae examined in this study, those of *H. ascita*, *H. bergi*, *H. cruralis*, *H. luctuosa*, and *H. pulla*, are similar in some respects. All are approximately cylindrical and tapered toward both

ends. In the third (last larval) instar, they range from 2.5x0.5 mm. to 6.0x1.0 mm. All are metapneustic, the only spiracles being slit-like openings near the tips of two sharp, hollow spines at the posterior ends of their bodies. Larvae are usually found with these spines inserted into plant tissue. Presumably they obtain oxygen from the intercellular gas spaces of plants by this means. The sclerotized anal plate, bearing a median longitudinal anal slit, is on the ventral surface a short distance anterior to these spines. On the ventral surface, anterior to the anal plate, there are eight well-defined and conspicuous spinulose areas used in locomotion (the "creeping welts" of authors). Anterior to them, three less prominent spinulose areas become progressively smaller and more diffuse toward the anterior end. The pharyngeal skeletons are relatively simple, and each bears a single mouth hook. This condition may not be constant for the genus, since Williams (1938) refers to the "pair of mouth hooks" of *H. williamsi* Cresson, and Wesenberg-Lund (1943) mentions the "Paar kleinen Mundhaken" of *H. modesta*. Anterior spiracles apparently are lacking. A pair of three-jointed sensory projections (the "antennae" of various authors) are borne near the anterior end of the body. Below these, just anterior to the mouth hooks, there is a pair of single-jointed tubercles which may also have a sensory function. All larvae possess some spinules or setae in addition to those on the creeping welts, but their sizes, numbers, and distribution patterns differ in larvae of different species.

Puparia of all species reared are light brown, subcylindrical, shorter and thicker than the larvae. They are 2.4–4.5 mm. in length and 0.7–1.5 mm. in maximum breadth. Vestiges of the larval respiratory spines, anal plates, creeping welts, and setal patterns are evident, and each puparium contains a larval pharyngeal skeleton and mouth hook. Puparia of *H. ascita*, *H. bergi*, and *H. caliginosa* differ from the other three species in being narrower and more elongate, tapering slowly and gradually toward the posterior end, and having the respiratory spines terminal. Puparia of *H. cruralis*, *H. pulla*, and *H. luctuosa* are more compact and taper more abruptly to their posterior ends. Their respiratory spines are subterminal, and their anal plates are more or less concave posteriorly. Emerging *Hydrellia* open their puparia by pushing off an anterodorsal portion ("dorsocephalic cap" of authors) including the terga of approximately the three thoracic segments. Unlike many emerging muscoid flies, which detach or at least loosen a corresponding ventral portion of their puparia containing the larval mouth hooks and pharyngeal skeletons, *Hydrellia* leave their puparia with ventral surfaces intact.

Newly emerged flies of these six species are hydrofuge, and they experience little difficulty in getting up through the surface film. They crawl up on some floating or emergent object and rest there for about five minutes, meanwhile brushing their bodies, especially the wrinkled wings, with their feet. Then the wings expand rapidly, reaching full size in about 45 seconds. They remain soft and useless for a few minutes after expanding. Adult flies alight and walk on the surface film without getting wet. They mate while resting on floating or emergent objects in the natural environment and lay their eggs on exposed portions of the food plant.

All *Hydrellia* mines encountered in this study are linear, and of uniform pale green color. They contain no conspicuous frass nor distinguishing marks caused by mouth hooks of the larvae. Those in leaf blades are usually near the midrib and parallel with it. Puparia, which are formed within larval mines, have the respiratory spines inserted in midribs or other vascular structures.

Hydrollia in various stages of their life cycles were brought into the laboratory for closer observation. Leaf-mining larvae thrived and pupated in finger bowls if fresh leaves were supplied as needed. Each puparium was cut out as soon as it filled with gas around the pupa and became buoyant, and was placed in about a centimeter of water in a small vial for individual rearing. Since the decay of excised plant material might produce conditions which would kill the pupa, I tried at first to take as little leaf tissue as possible with each puparium. It was found, however, that too little plant tissue may constitute a greater hazard than too much. The margins of the excised plant material become waterlogged. If it is so small that water penetrates to the respiratory spines, the puparium fills with water and sinks, and the pupa dies.

A higher percentage of adult flies can be obtained by keeping whole leaves or whole plants containing the puparia alive in screen-covered bowls or aquaria. If individual rearing is desirable and time for daily examination of the puparia is available, each puparium can be cut out when the pupa within it turns dark and transferred to a stoppered vial containing a small amount of water.

KEY TO LARVAE AND PUPARIA OF HYDRELLIA WHICH INFEST POTAMOGETON IN MICHIGAN

A. Larva relatively broad, maximum breadth about 16 per cent of length, shape similar to that of *H. cruralis* (Pl. I, fig. 8); puparium (Pl. III, figs. 1, 4, 5) fairly compact, with respiratory spines subterminal; dorsal setae at least in intersegmental grooves of all abdominal segments, apparent with low power of compound microscope; pharyngeal skeleton (Pl. II, figs. 1, 4, 5) with relatively long, narrow shank, dimension between its ventral projections at least 2.3 times the breadth midway between projections . . . . .B

    B. Small species, mature larvae less than 4.8 mm. long; puparium (Pl. III, fig. 1) 3.5 x 1.1 mm. or smaller, tapered more gradually posteriorly than anteriorly, posterior margin of anal plate only slightly concave; dorsal setae abundant, generally dispersed, in irregular transverse rows; pharyngeal skeleton (Pl. II, fig. 1) pigmented throughout, with dorsal rods opaque black . . . .**luctuosa**

    BB. Larger species, mature larva more than 4.8 mm. long; puparium (Pl. III, figs. 4, 5) 3.5 x 1.0 mm. or larger, ovoid, abruptly tapered at both ends, posterior margin of anal plate strongly concave; dorsal setae fewer, concentrated in or near intersegmental grooves; pharyngeal skeleton (Pl. II, figs. 4, 5) less extensively pigmented, with dorsal rods colorless C

        C. Mature larva (Pl. I, fig. 8) leaf-green; puparium (Pl. III, fig. 4) constricted between segments laterally, giving it a scalloped appearance; dorsal abdominal setae confined to narrow bands in intersegmental grooves; pharyngeal skeleton (Pl. II, fig. 4) usually colored as shown, rarely almost as light as that of *H. pulla* . . . .**cruralis**

        CC. Mature larva grayish cream color; puparium (Pl. III, fig. 5) without scalloped appearance, little if any constriction between segments; bands of dorsal abdominal setae wider, composed of distinct transverse rows; pharyngeal skeleton (Pl. II, fig. 5) always very sparsely pigmented . . . .**pulla**

AA. Larva relatively narrow, maximum breadth about 9 per cent of length, shape similar to that of *H. bergi* (Pl. I, fig. 1); puparium (Pl. III, figs. 2, 3) elongate, tapered gradually to posterior end, with respiratory spines terminal; most abdominal segments usually without dorsal setae; pharyngeal skeleton (Pl. II, figs. 2, 3, 6) with relatively short, stout shank, dimension between its ventral projections less than 2.3 times the breadth midway between projections...D

    D. Larger species, puparium (Pl. III, fig. 3) usually more than 3.7 mm. long; pharyngeal skeleton (Pl. II, fig. 3) with distinct hump above cheliform spot, opaque black pigment continuous from cheliform spot posteriorly to dorsoventral fork, ventral rods longer than portion anterior to dorsoventral fork; mouth hook stout. Miner in stems and petioles but not in leaf blades...**bergi**

    DD. Smaller species, puparium (Pl. III, fig. 2) usually less than 3.7 mm. long; pharyngeal skeleton (Pl. II, figs. 2, 6) without hump above cheliform spot, usually lacking opaque black pigment behind cheliform spot, ventral rods no longer (usually considerably shorter) than portion anterior to dorsoventral fork; mouth hook narrower. Miners in leaf blades only.................E

      E. Dorsal setae lacking on all abdominal segments except first, second and last; pharyngeal skeleton (Pl. II, fig. 2) with only diffuse pigment behind cheliform spot............................**ascita**

      EE. Dorsal setae at least in intersegmental grooves of all abdominal segments; pharyngeal skeleton (Pl. II, fig. 6) with opaque black pigment continuous from cheliform spot posteriorly to dorsoventral fork. Rare on *Potamogeton* in Michigan. Larva not observed....................**caliginosa**

Hydrellia cruralis Coquillet

The literature contains five records of *Hydrellia* larvae mining in *Potamogeton* which probably refer to *H. cruralis*. Moore (1915), working near Ithaca, New York, found the leaves of *P. amplifolius* mined by *Hydrellia* larvae. Frost (1924) cited Moore's work and stated, "*Hydrellia* n. sp. . . . mines in the leaves of *P. amplifolius*." Johannsen (1935) identified a single specimen presumably reared by Moore as *Hydrellia cruralis*. Johannsen suggested, however, that this specimen might have been incorrectly labelled, and this record remains in doubt. Cresson (1934) reported specimens of this species reared from *Potamogeton* sp. by Miss Gertrude Auxier, at Marlington, West Virginia. Cresson (1944) wrote of *H. cruralis*, "A relatively common northern species and which has been bred from pondweed in Michigan." While not so stated, it seems probable that this last record is based on material reared in this investigation and sent to Cresson for identification on September 1, 1940, March 18, 1941, and October 27, 1941.

During this study, *H. cruralis* was encountered more frequently than any other species of *Hydrellia*. Immature specimens were collected in Cheboygan, Emmet, Presque Isle, and Washtenaw Counties, Michigan. Larvae and pupae were found in the leaves of *Potamogeton alpinus*, *P. amplifolius*, *P. epihydrus*, *P. foliosus*, *P. gramineus*, *P. illinoensis*, *P. natans*, *P. nodosus*, *P. praelongus*, *P. Richardsonii*, and *P. zosteriformis*. In order of decreasing extent of infestation, the species which harbored the greatest numbers of *H. cruralis* were *P. amplifolius*, *P. Richardsonii*, *P. praelongus*, *P. gramineus*, *P. illinoensis*, and *P. nodosus*.

Egg (Pl. I, fig. 5).—Elongate, cylindrical, rounded at both ends; 0.5–0.6x0.12–0.17 mm.; central yolk mass opaque, cream color or faintly yellow; peripheral translucent zone wider at both ends; chorion delicately sculptured with irregular longitudinal furrows; micropyle terminal with lips flared, bell-shaped.

First Larval Instar (living).—Cylindrical and tapering abruptly at both ends; length 0.8–1.5 mm.; color uniform throughout; at first cream color, later becoming greenish; creeping welts relatively large, conspicuous; pharyngeal skeleton 0.15–0.19 mm. long, lightly pigmented throughout, darkly pigmented in same areas as those of third instar pharyngeal skeleton.

Second Larval Instar (living).—Shape unchanged except creeping welts relatively less conspicuous; length 1.5–3.0 mm.; color, leaf green; pharyngeal skeleton 0.27–0.29 mm. long, color pattern same as that of third instar pharyngeal skeleton.

Third Larval Instar (living) (Pl. I, fig. 8).—Length 3.0–5.5 or 6.0 mm.; breadth 0.7–1.0 mm.; color usually green, but variable, tends to match color of leaf; ventral setal pattern similar to that of puparium (Pl. III, fig. 4); dorsal setae in transverse rows confined to intersegmental furrows; setae dispersed laterally; each creeping welt fusiform, bearing 8 to 13 irregular transverse rows of spinules (Pl. I, fig. 6); anal plate ovoid; anal and postanal regions armed with spinules which become heavier and often double posteriorly; terminal respiratory spines set on small papillae; anterior end (Pl. I, fig. 7) supplied with paired, 3-segmented antennae, paired, one-segmented inferior tubercles, single median mouth hook, and post-oral tuft of fine hairs; pharyngeal skeleton (Pl. II, fig. 4) 0.40–0.62 mm. long, usually dark anteriorly as shown, but rarely almost as light as that of *H. pulla* (Pl. II, fig. 5), slight hump above cheliform black spot.

Puparium (Pl. III, fig. 4).—3.5–4.5x1.1–1.5 mm.; transparent golden brown; ovoid, subcylindrical, with laterally distinct intersegmental furrows giving puparium scalloped appearance; setal pattern as shown and as discussed for larva; anal plate crescent shaped with rounded ends; respiratory spines subterminal; pharyngeal skeleton as described for third instar larva; pupa within greenish, becoming olivaceous gray shortly before emergence.

Biology.—Eggs are deposited on or in the emergent portions of food plants. They are usually laid side by side in compact masses one layer deep, with all eggs of a mass oriented in the same direction. Apparently the female attempts to lay eggs in a concealed or protected situation. In breeding cages, most of the eggs were inserted into exposed intercellular air spaces in broken midribs of leaves and into torn openings in old mines. Others were found on strips of paper hanging over the water, on floating leaves, and, in a few instances, floating unattached. The oviposition which was observed was always at the surface of the water. In nature, egg masses were found in folds of leaves, in curled stipules, and on stems.

Within limits, speed of development increases with rising temperaature. After one to five days of embryonation the completely formed larva is visible through the egg shell. The active pharyngeal skeleton is particularly apparent.

From two to seven days after the egg is laid, the larva cuts a slit in one end of the egg shell and emerges. It bores directly into the leaf and begins to mine in the mesophyll between the upper and lower epidermis. In two or three days the larva has grown to a length of 1.5 mm., and the first molt occurs. The exuviae, including the pharyngeal skeleton, are left in the mine.

Mines of *H. cruralis* in thin, submerged leaves of *Potamogeton* are equally visible from either side, and are most readily seen by examining the leaves with transmitted light. Mines in coriaceous floating leaves are just within the lower epidermis and are visible only from the lower side by use of reflected light.

The larva selects fresh food. If the leaf in which it is mining dies, it cuts through the epidermis, migrates to a greener leaf, and starts a new mine. Six second stage larvae which were mining in a leaf that had begun to turn brown entered a fresh, green leaf within 12 hours after it had been supplied.

That selection of newer, greener leaves also occurs in nature is evident from repeated observations on *Potamogeton Richardsonii*. A lower leaf often has a mine which contains the cast exoskeleton of the first stage larva. The mine in the leaf immediately above it contains exuviae of the second stage larva. The next leaf is mined but empty, and the fourth leaf contains the mature larva or the puparium.

Under laboratory conditions, the duration of the second stadium is about 5 to 8 days; that of the third, approximately 10 to 18 days. Then the mature larva usually takes a position where the mine is in contact with the midrib. The respiratory spines are inserted into the midrib, the body is contracted to assume the proportions of the puparium, and the body wall becomes sclerotized in this position. Two days later, the greenish pupa is visible within the transparent brown puparium. Ten to 14 days usually elapse between cessation of larval movement and emergence of the adult. During unusually hot weather, a group of adults once emerged only eight days after cessation of larval movement.

Emergence and early activities of the adult, observed during daylight hours ranging from 10:00 a. m. to 5:00 p. m., are as described for all five species in the introductory section. Young flies, prodded to test their avoiding reactions 15 minutes after emergence, escaped only by walking and by darting an inch or two. Since they could be forced to fall, it is evident that they could not fly effectively. This would seem to indicate that flies emerging in rough water must suffer considerable hazard of drowning. Twenty-five minutes after emergence they flew readily and well.

The adult feeds on *Potamogeton* leaves, chewing small holes in them. Scotland (1934) and Williams (1938) reported similar habits in closely related species of Ephydridae. However, the fly is not exclusively phytophagous. They often dismember and devour the bodies of other flies which die in the rearing bottle.

The reared flies mated within 24 hours after emergence, and laid eggs within 24 hours after mating. The life cycle was completed several times in the laboratory. It had a duration of 32–53 days; average of 24 records, 41 days.

In nature, the first adults of the season seem to appear at about the

24th of May in Washtenaw County, Michigan, and can be found continuously until approximately the middle of October. Thus, at least three generations per season are possible. However, no distinct emergence heights were observed. It seems that all stages of the life cycle may be found on any date during late spring, summer, and early autumn. A single plant from a summer collection may harbor eggs, all three larval instars, pupae, and empty puparia.

Larvae of *H. cruralis* were collected throughout the winter in green leaves of *P. amplifolius*, the winter form of which was described by Moore (1915) as follows: "In *P. amplifolius* the tip ends of the branches function as propagative structures. . . . These structures appear in the autumn developing only at the tips of branches. The internodes are short and thick and densely packed with starch. At the end there are a few partially unfolded leaves which continue to grow slowly or, at least, remain green all winter. These rapidly expand when the roots develop in the spring and the entire structure forms an effective and rapid means of propagation."

When other leaves of the food plant turn brown and begin to disintegrate in autumn some larvae migrate to these propagative structures and enter the new leaves. They become less and less active as the water cools, finally reaching a state of quiescence. Specimens representing all three larval instars were found thus hibernating in plants beneath the ice, but no other stages of the life cycle were collected during the winter. Specimens collected as larvae in midwinter and placed in an aquarium at laboratory temperature soon became active, resumed feeding, pupated, emerged, mated, and laid fertile eggs. In one instance, the larvae which hatched from such winter eggs were also reared to maturity.

Muller (1922), failing to find the young larvae of *H. flavicornis* Fall., speculated on where and how young *Hydrellia* larvae live. Williams (1938) watched the development of a single laboratory-hatched specimen of *H. williamsi*, but to date very little is known concerning the biology of young *Hydrellia* larvae of any species.

Observations on laboratory-hatched and wild specimens of *H. cruralis* indicate that failure to find first and second stage larvae of *Hydrellia* in nature is probably due chiefly to the great difficulty involved in seeing them. They match the color and optical density of leaves so perfectly that it is very difficult to find them even by carefully examining each leaf with a dissecting microscope. After the larva has been located by detecting movements of its minute pharyngeal skeleton and mouth hook it usually takes a few more seconds of careful scrutiny to distinguish the outline of its body.

The problem is further complicated in fresh winter collections because the torpid larvae make no movements which might disclose their presence. Within 24 hours after winter collections have been brought into the laboratory some larvae can usually be found actively mining in the rolled lower regions of partially opened leaves. Careful examination usually results in finding only a small fraction of the larvae present, however, and it seems advisable to keep all winter collections in aquaria at room temperature for three weeks before making a final check for the presence of *Hydrellia*.

Some *P. amplifolius*, collected under ice 12 inches thick at Third Sister Lake, Washtenaw County, Michigan, January 9, 1941, was carefully examined after it had stood in a warm laboratory for 24 hours. Four actively mining larvae of *H. cruralis*, three third and one second instar, were found and put into a rearing bottle.   The examined plant material was placed in an aquarium which was freshly made up with tap water and kept at laboratory temperature.   On January 29, 20 days after the collection was made, a re-examination of the growing plants revealed 11 third stage larvae and 23 puparia of this species.

Hymenopterous parasites of five species were reared from puparia of *H. cruralis*.   The braconids *Ademon niger* (Ashmead) and *Chorebidea* sp. 1, and the diapriid *Trichopria columbiana* (Ashmead) were encountered occasionally to commonly during their respective seasons.   Single specimens representing *Chorebidella* sp. and an unidentified genus of the family Pteromalidae were also obtained.

Hydrellia pulla Cresson

Johannsen (1935) stated that Moore had reared a specimen of *Hydrellia pulla* from *Potamogeton* near Ithaca, New York.   The only other published note concerning the biology of this species appears to be that of Cresson (1944), who wrote, "A scarce northern species, associated with pondweed."   This record was probably based partly on Johannsen's published statement, and partly on material reared in this investigation and sent to Cresson for identification on September 1, 1940, March 18, 1941, and October 27, 1941.

Specimens of this species were collected in Cheboygan and Washtenaw Counties, Michigan.   Larvae mine in the leaves of *Potamogeton amplifolius*, *P. gramineus*, and *P. Richardsonii*.

Egg (Pl. I, fig. 4).—General shape like that of *H. cruralis* except for greater thickness, and end opposite micropyle is pointed; 0.57–0.65x 0.18–0.22 mm.; central yolk mass opaque, grayish brown color of variable intensity; surrounded by narrow translucent zone; longitudinal sculpturing of chorion more vague and obscure than on *H. cruralis* eggs; terminal micropyle projection longer than that of *H. cruralis*.

First Larval Instar (living).—Cylindrical and tapering abruptly at ends, with creeping welts conspicuous, protruding; length 1.0–1.8 mm.; color grayish cream throughout; apparently 12-segmented; pharyngeal skeleton 0.18–0.22 mm. long, darkly pigmented in same areas as those of third instar pharyngeal skeleton, with diffuse pigment throughout all other regions.

EXPLANATION OF PLATE I

Eggs and larvae of *Hydrellia* (Ephydridae).   FIG. 1. *Hydrellia bergi:* Lateral view of whole larva.   FIG. 2. *H. bergi:* Lateral view of anterior end of larva. FIG. 3. *H. bergi:* Egg.   FIG. 4. *Hydrellia pulla:* Egg.   FIG. 5. *Hydrellia cruralis:* Egg.   FIG. 6. *H. cruralis:* Ventral view of posterior end of larva.   FIG. 7. *H. cruralis:* Lateral view of anterior end of larva.   FIG. 8. *H. cruralis:* Lateral view of whole larva.   a, antenna; a. pl., anal plate; a. s., anal slit; c. w., creeping welt; i. t., inferior tubercle; m., micropyle; m. h., mouth hook; p. s., pharyngeal skeleton; r. sp., respiratory spine.

Diptera Reared from Potamogeton
Clifford O. Berg

PLATE I

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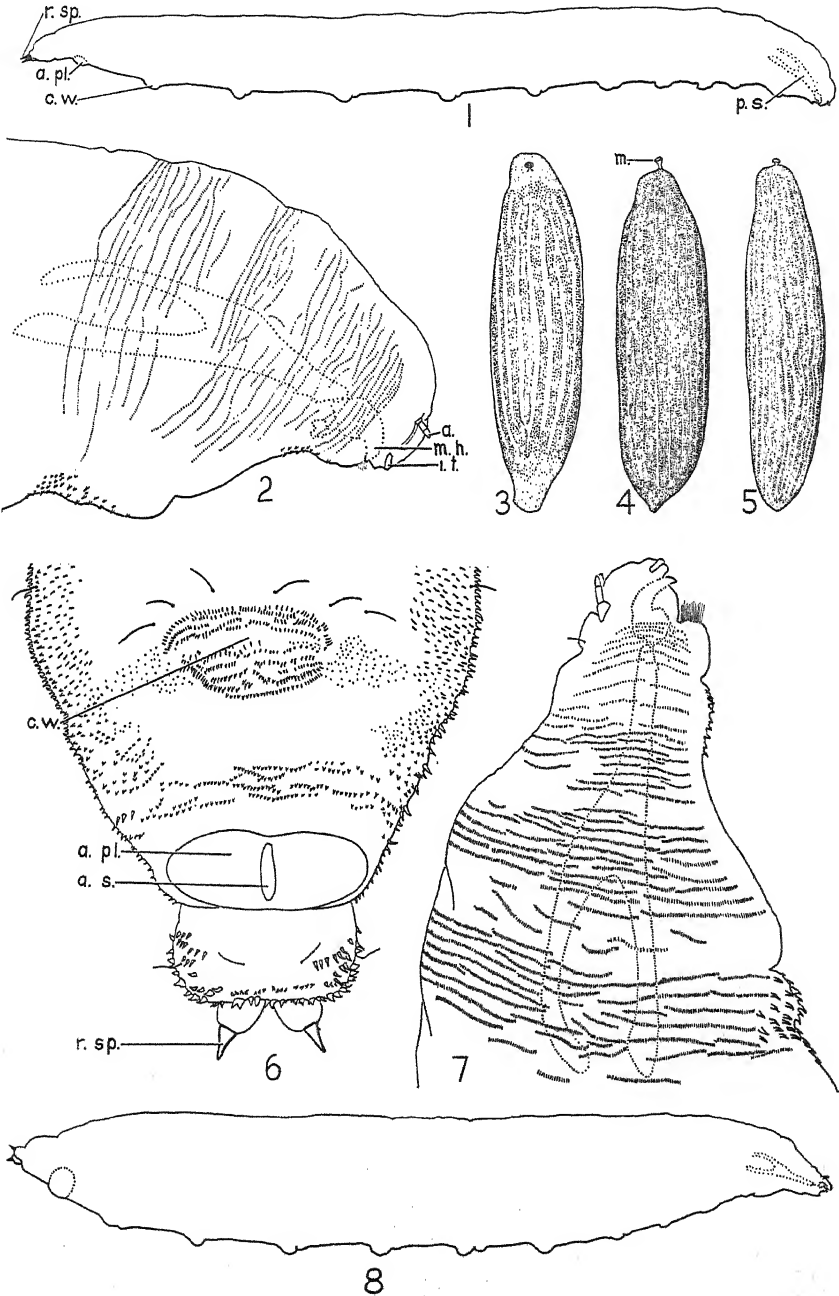
Second Larval Instar (living).—Color and shape unchanged except creeping welts less conspicuous; length 1.8–3.5 mm.; pharyngeal skeleton 0.28–0.35 mm. long, with color pattern same as that of third instar.

Third Larval Instar (living).—Color and shape unchanged, the latter like that of *H. cruralis* (Pl. I, fig. 8); length 3.5–6.6 mm.; breadth 0.8–1.1 mm.; ventral setal pattern similar to that of puparium (Pl. III, fig. 5); transverse rows of dorsal setae tend to concentrate toward intersegmental furrows, but more dispersed than on *H. cruralis*; setal rows curved and running in various directions laterally; posterior end similar to that of *H. cruralis*, (Pl. I, fig. 6) with terminal respiratory spines short, anal plate ovoid, but no heavy, double spinules on postanal region; anterior end shaped like that of *H. cruralis*, with three-segmented antennae, one-segmented inferior tubercles, single median mouth hook, and postoral tuft of fine hairs; pharyngeal skeleton and mouth hook (Pl. II, fig. 5) light colored, and lacking hump above cheliform black spot, pharyngeal sclerite 0.50–0.65 mm. long.

Puparium (Pl. III, fig. 5).—3.5–4.5x1.0–1.5 mm.; transparent light brown; ovoid, subcylindrical, lacking distinct intersegmental furrows and scalloped appearance of *H. cruralis*; setal pattern as shown and as discussed for larva; anal plate strongly concave posteriorly with bluntly rounded ends, and not so crescent shaped as on *H. cruralis*; respiratory spines subterminal; pharyngeal skeleton (Pl. II, fig. 5) as described for third instar; pupa light colored, appearing yellowish brown through brown puparium, then turning darker and becoming almost black shortly before emergence.

Biology.—Eggs were found in nature during June, July, and August on floating or emergent portions of food plants. They are usually laid, like those of *H. cruralis*, side by side in compact masses one layer deep, often in such concealed situations as folds of leaves, ends of old mines, and in sheathing stipules. In the laboratory, they were laid on emergent parts of the food plant, free on the water surface, and stuck to the side of the rearing bottle.

Embryonation is accelerated by increased temperature. From two to four days after oviposition, the active larva becomes visible through the egg membranes. The eggs hatch in four to six days.

The newly hatched larva enters a leaf and begins to mine at once. In four to eight days it has grown to a length of about 2.2 mm., and the first molt occurs. Six to 10 days later, the larva molts again. The exuviae, including pharyngeal skeletons, of the first two instars are left in the mine.

Remarkable concentrations of *Hydrellia* sometimes result from the larva's tendency to migrate into younger, greener leaves. Three young

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EXPLANATION OF PLATE II

Pharyngeal skeletons and mouth hooks of *Hydrellia* (Ephydridae). FIG. 1. *Hydrellia luctuosa*. c. s., cheliform spot; d. r., dorsal rods; m. h., mouth hook; v. r., ventral rods. FIG. 2. *Hydrellia ascita*. FIG. 3. *Hydrellia bergi*. FIG. 4. *Hydrellia cruralis*. FIG. 5. *Hydrellia pulla*. a. p., length of portion of pharyngeal skeleton anterior to dorso-ventral fork; l., total length of pharyngeal skeleton; s., breadth of shank; v. p., dimension between ventral projections; v. r., length of ventral rods. FIG. 6. *Hydrellia caliginosa*.
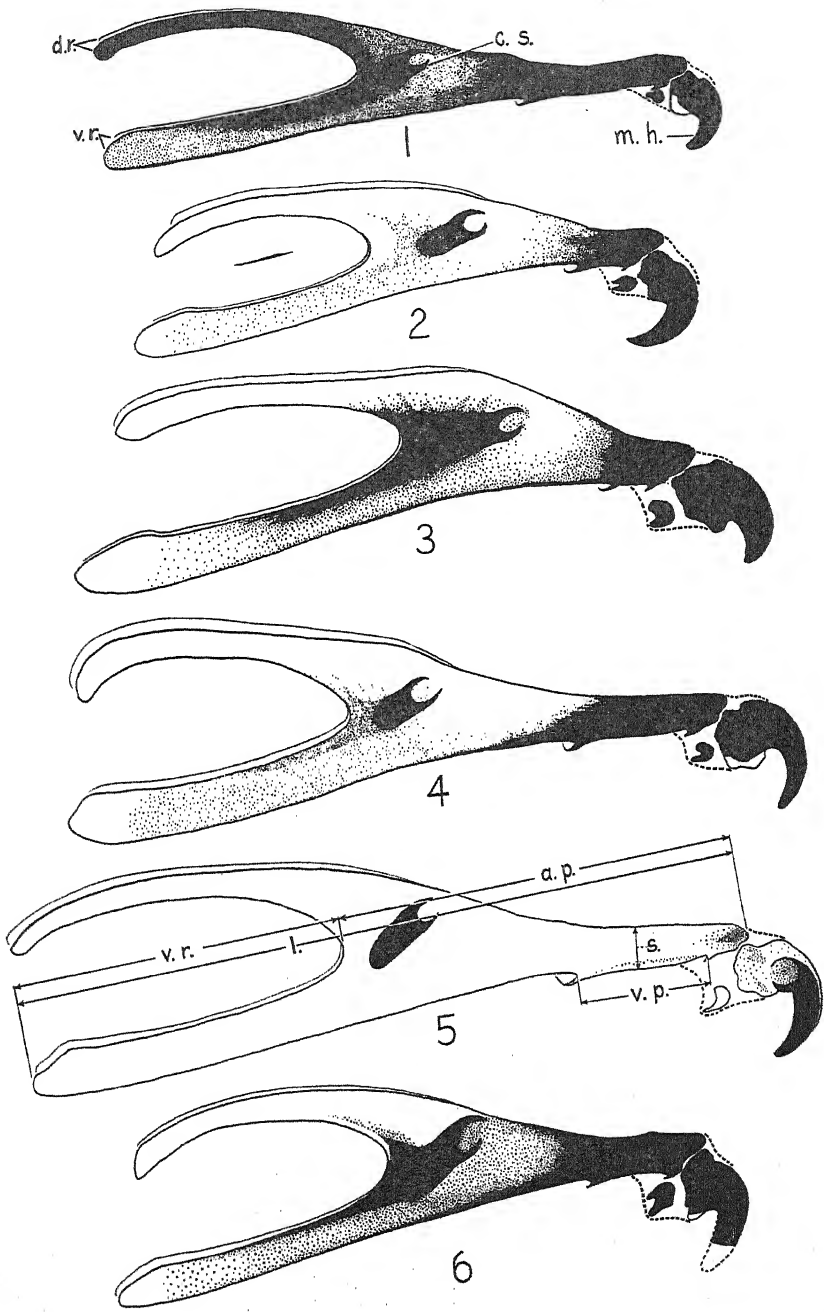
leaves of *P. amplifolius* collected May 3, 1942, at Third Sister Lake, Washtenaw County, Michigan, contained 8, 10, and 12 puparia, respectively. Each plant was composed of several tattered, brown leaves formed the previous autumn and one or two new green ones. Mines in the old leaves were empty, the larvae having migrated into the new leaves.

Under laboratory conditions, the duration of third stadium is approximately 8 to 15 days. Then the larva usually extends the mine into contact with the midrib and parallel with it, inserts the respiratory spines into the midrib, and contracts the body to assume the size and shape of the puparium. The body wall sclerotizes, and two days later the light colored pupa is visible within the puparium. Ten to 15 days usually elapse between cessation of larval movement and emergence of the adult.

It may be that emergence, which was observed repeatedly through a dissecting microscope, is hastened by radiations from the microscope lamp. A remarkably high percentage of emergences were witnessed when compared with the percentage of time that puparia were under observation. In this process there are intervals of activity and of rest. The imago grips the wall of the puparium with all six tarsi and pushes forward until an anterodorsal portion of the puparium ("dorso-cephalic cap" of authors) is detached and the fly crawls out.

Newly emerged adults are unable to fly until a few minutes after their wings have expanded. Young, flightless adults of *H. pulla* avoid the heat and intense light of the microscope lamp by crawling onto the shaded sides of available objects. Adult flies in the rearing bottle exhibited the activities described in the general section and for *H. cruralis*.

Laboratory reared *H. pulla* mated and laid eggs within 48 hours after emergence. Life cycles observed had a duration of 34 to 55 days; average of seven records, 43 days.

Seasonal aspects of *H. pulla* are similar to those reported above for *H. cruralis*. Adults are found in Washtenaw County, Michigan, continuously from late May through early October. No emergence heights were observed. This species passes the winter as a torpid larva in the leaves of its food plants.

Apparently *H. pulla* is much less susceptible to parasitism than any other species of *Hydrellia* studied in this investigation. Although *pulla* was often observed closely associated with *H. cruralis*, the two braconid parasites *Chorebidea* and *Ademon*, so frequently reared from the latter, were never encountered in puparia of the former.[2] The only species of parasite reared from puparia of *H. pulla* was the diapriid *Trichopria columbiana* (Ashmead).[3]

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[2]Seven puparia of *H. pulla* and five puparia of *H. cruralis* were found in a single leaf of *P. amplifolius* collected in Third Sister Lake, Washtenaw County, Michigan, May 3, 1942. There was no case of parasitism among the 80 *H. pulla* puparia in this collection, but 12 of the 71 *H. cruralis* puparia harbored braconid parasites.

[3]It is evident that *Hydrellia* may be used as food by fishes. The stomach of a bluegill (*Lepomis macrochira*) caught by R. C. Ball in Third Sister Lake, August 13, 1940, contained seven puparia of *H. pulla*. In another bluegill stomach, puparia of both *H. pulla* and *H. cruralis* were found.

Hydrellia luctuosa Cresson

Hydrellia luctuosa was described (Cresson, 1942) from specimens reared in this study. It appears that the only other published note on this species is that of Cresson (1944), who wrote, "A rare species from Michigan, reared from pondweed." It seems probable that this record was based solely upon the type series which was reared during the summer of 1941 and sent to Cresson during October of that year.

Specimens of *H. luctuosa* were collected in several localities in Cheboygan County, Michigan. In the order of preference, food plants of the larvae seem to be *Potamogeton alpinus*, *P. zosteriformis*, *P. Richardsonii*, *P. amplifolius*, and *P. natans*, infestation of *P. amplifolius* and *P. natans* being relatively uncommon.

Egg and first larval instar were not observed.

Second Larval Instar (living).—2.0–3.2 mm. long; relatively stout; grayish cream color; pharyngeal skeleton similar to that of third instar in shape and color, 0.26–0.31 mm. long.

Third Larval Instar (living).—Shape and color unchanged, similar to those of *H. pulla*; about 4.2x0.6 mm.; ventral setal pattern as shown for puparium (Pl. III, fig. 1); dorsal and lateral setae abundant, in irregular transverse rows, generally dispersed; pharyngeal skeleton (Pl. II, fig. 1) slender, heavily pigmented, 0.40–0.48 mm. long.

Puparium.—(Pl. III, fig. 1) Transparent brown: 2.7–3.6x0.7–1.1 mm.; taper toward posterior end more abrupt than that of *H. bergi* and *H. ascita*, not so abrupt as *H. cruralis* and *H. pulla*; respiratory spines subterminal; setal pattern as shown and described for larva; enclosed pharyngeal skeleton (Pl. II, fig. 1) as described for larva.

Biology.—The eggs were not found in nature, and attempts to secure them from reared flies were unsuccessful.

The larvae mine in the mesophyll layer between the upper and lower epidermis of thin submerged leaves. When, rarely, they mine in floating leaves they work just within the lower epidermis and are visible only from the under side.

Little is known about the seasonal behavior of *H. luctuosa*. Puparia appeared in nature as early as July 3 in 1941, and both larvae and puparia could be found throughout July and August.

H. luctuosa is parasitised by the diapriid *Trichopria columbiana*, and by the braconid *Dacnusa* sp. 2.

Hydrellia bergi Cresson

Hydrellia bergi was described (Cresson, 1941) from specimens reared in this investigation. The only other published reference to this species seems to be that of Cresson (1944), who wrote, "Not a common species, and known only from Michigan, where it has been bred from pondweed."

Specimens of *H. bergi* were collected in Cheboygan, Presque Isle, and Washtenaw Counties, Michigan. Larvae and pupae were extracted from longitudinal mines just within the epidermis of stems, quill-like submerged leaves, and petioles of *Potamogeton natans*, but were not found in leaf blades. A few larvae were also collected from mines in stems of *P. Richardsonii* and *P. zosteriformis*.

Egg (Pl. I, fig. 3).—Elongate, cylindrical, with ends more nearly truncate than those of *H. cruralis* and *H. pulla*; 0.6–0.7x0.17–0.20 mm.; longitudinal sculpturing of chorion very evident on exposed side of egg, but obscure on attached side; micropyle inconspicuous, subterminal, on exposed side.

First Larval Instar (known from exuviae only).—Pharyngeal skeleton and mouth hook shaped and colored like that of third instar (Pl. II, fig. 3); pharyngeal sclerite 0.16–0.18 mm. long.

Second Larval Instar (living).—Shape similar to third instar, relatively narrower than that of *H. cruralis*; length 1.5–3.0 mm.; color greenish yellow; pharyngeal skeleton similar to that of third instar except for small size; pharyngeal sclerite 0.25–0.27 mm. long.

Third Larval Instar (living).—(Pl. I, fig. 1) Relatively narrower and more elongate than that of *H. cruralis*, *H. pulla*, and *H. luctuosa*; 5.2x0.58 mm.; color predominantly greenish yellow, with intestinal contents often showing through as a deep brown, surrounded by yellow orange area; ventral setal pattern similar to that of puparium (Pl. III, fig. 3); setae generally distributed over dorsal and lateral surfaces of pseudocephalic segment (Pl. I, fig. 2); posteriorly, dorsal and lateral setae occur only in bands in intersegmental furrows; the bands gradually become narrower posteriorly, the last one which completely girdles larva being in furrow between first and second abdominal segments; on following segments setae almost solely ventral, except on last, which is completely girdled by somewhat larger spinules; anterior end provided with structures illustrated and discussed under *H. cruralis*; pharyngeal skeleton and mouth hook (Pl. II, fig. 3) relatively stout, with definite hump above cheliform spot, the posterior boundary of which is obscured by concentration of black pigment; pharyngeal sclerite 0.42–0.52 mm. long; posterior end more gradually tapered than that of *H. cruralis*, with relatively longer respiratory spines; anal plate ovoid.

Puparium (Pl. III, fig. 3).—3.5–4.5 x 0.8–1.0 mm.; transparent light brown; distinctly more elongate and more gradually tapered posteriorly than that of *H. cruralis*, *H. pulla*, and *H. luctuosa*; respiratory spines terminal; anal plates ovoid with no concavity of posterior margin; setal pattern as shown and as described for larva; enclosed pharyngeal skeleton and mouth hook as figured and described for larva; pupa light colored at first, then developing pigment in compound eyes, then in body generally, becoming predominantly black before emergence.

Biology.—Eggs of *H. bergi* were deposited in the laboratory on stems of *P. natans* and attached to the side of the rearing bottle. In nature a similar egg mass was found attached to a stipule of *P. natans*. Unfortunately, none of these eggs hatched, and no information was obtained concerning embryonation, hatching, nor the newly hatched larva.

EXPLANATION OF PLATE III

Puparia of *Hydrellia* (Ephydridae). Fig. 1. *Hydrellia luctuosa.* Fig. 2. *Hydrellia ascita.* (Lateral curvature near posterior end of no significance.) Fig. 3. *Hydrellia bergi.* Fig. 4. *Hydrellia cruralis.* Fig. 5. *Hydrellia pulla.* Abbreviations as in Plate I.
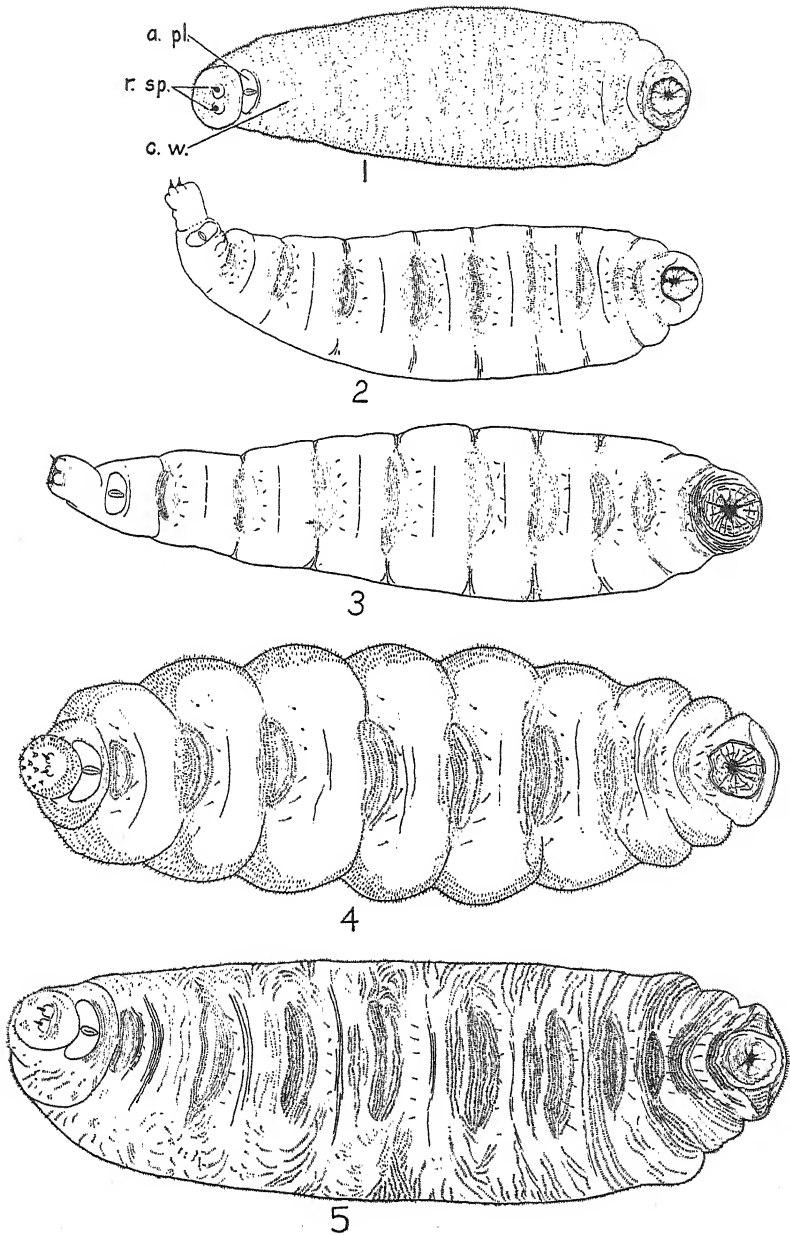
In biological aspects, larvae of *H. bergi* seem quite similar to those of *H. cruralis* and *H. pulla*. Since the stems in which they mine are thick and opaque, these larvae cannot be found by examination of plants with transmitted light. Some mines can be located because the epidermis covering them appears somewhat collapsed, and larvae were found only after opening such mines. Puparia can often be detected without dissection of plant tissue because the epidermis over them bulges outward and the dark color of mature pupae is often visible through the epidermis.

Just before pupation the larva provides for emergence of the adult by cutting a U-shaped incision in the epidermis of the stem. A similar provision is made by the larva of *Hydromyza confluens* Loew (Needham, 1908; Welch, 1914), a cordylurid species which pupates in petioles of the yellow water lily. The incisions made by larvae of these two species are similar in several respects. They are always cut in the epidermis covering the anterior ends of puparia. Both types are of such form as to produce lids which open readily when gentle pressure is applied from within. Both types of lids are attached along the side nearest the posterior end of the puparium.

Provisions for emergence in the two species differ in the following respects: (1) The incision made by *H. confluens* is in the shape of an arc extending approximately two-thirds the circumference of a circle (Welch, 1914) and has convergent ends; the incision made by *H. bergi* produces a U-shaped lid which is elongated in the longitudinal axis of the puparium and has parallel or slightly divergent ends. (2) The epidermal incision made by *H. bergi* is continuous, leaving no strands of tissue to hold the lid closed until the time of emergence. (3) Since *H. bergi* pupates just beneath the epidermis, there is no passage communicating between puparium and epidermal incision like that provided by *H. confluens*, which pupates deeper within the plant tissue.

H. bergi is the only species of *Hydrellia* herein discussed which provides for emergence of the adult in the manner described above. This is probably correlated with the fact that all other species of the genus reared during this investigation pupate in leaves, the epidermis of which is relatively thin and delicate and easily ruptured by the escaping imago.

In a few instances, puparia of this species were found with only their respiratory spines and posterior ends embedded in the *Potamogeton* stem, the greater part of these puparia protruding nakedly into the water. Such uncovered puparia were invariably found in leaf axils, where they looked very much like axillary buds. Perez (1901) described a similar habit in what appears to be a species of *Hydrellia* living on "*P. pectinatum*" in Europe.

In seasonal aspects, *H. bergi* is similar to the other species of *Hydrellia* discussed here. Emergence is not in well defined broods, but seems to be continuous throughout the summer. Both larvae and pupae were found in all eight collections of *P. natans* spread through two summer months in 1940 as follows: June 10, 20, 29, July 7, 20, 28, August 1, 9. Apparently this species passes the winter as a larva on the food plant. Larvae were taken in Washtenaw County, Michigan, on May 3, 1941, several weeks before adults were collected in nature.

Braconidae of three species, *Ademon niger* (Ashmead), *Chorebidea* sp. 2, and *Dacnusa* sp. 1, and the diapriid *Trichopria columbiana* (Ashmead) were reared from puparia of this fly.

Hydrellia ascita Cresson

Hydrellia ascita was described (Cresson, 1942) from flies which I reared during this study. Apparently the only other published reference to this species is that of Cresson (1944), who wrote, "Bred from pondweed of Michigan. Rare."

Specimens were found in several localities in Cheboygan County, and in Carp River, Emmet County, Michigan. Larvae mine in leaves of *Potamogeton alpinus*, *P. amplifolius*, *P. epihydrus*, *P. foliosus*, *P. illinoensis*, *P. Oakesianus*, *P. Richardsonii*, and *P. zosteriformis*.

Cresson designated only the flies reared from *P. alpinus* (—*P. tenuifolius*) collected at Nigger Creek, Cheboygan County, in his type series, and he identified the others as a variety of *H. ascita*. I am not able to distinguish larvae and puparia of the variety from those of the typical *H. ascita*.

During the summer of 1949, while Research Associate at Cranbrook Institute of Science, Bloomfield Hills, Michigan, I reared flies of this species extensively from *P. foliosus* growing in Sodon Lake, Oakland County.[4] Parasitic Hymenoptera representing a species not previously associated with *H. ascita* were reared at Sodon Lake, the first instar larva of *H. ascita* was observed, and additional information was gained concerning mining and pupation of the larvae within the very narrow leaves of *P. foliosus*.

Egg masses resembling those of other species of *Hydrellia* were found on leaves of *P. alpinus*. Since the source of these eggs is unknown, and since they failed to hatch, their identity remains in doubt.

First Larval Instar.—About 0.8–1.2 mm. long; anterior seven intersegmental furrows each with a band of setae; creeping welts relatively larger and more conspicuous than on older larvae; pharyngeal skeleton fuscous throughout except for black cheliform spot and mouth hook, 0.16–0.18 mm. long.

Second Larval Instar (living).—Similar to third instar in shape and color; length 1.2–2.4 mm.; pharyngeal skeleton colored like that of third instar, 0.23–0.29 mm. long.

Third Larval Instar (living).—Quite similar to *H. bergi* (Pl. I, fig. 1) in shape, color, and setal patterns, but smaller; 2.4–5.0x0.6–0.8 mm.; pharyngeal skeleton and mouth hook as shown (Pl. II, fig. 2), 0.35–0.49 mm. long.

Puparium (Pl. III, fig. 2).—Very similar to that of *H. bergi* in shape, color, and setal patterns, but smaller; 2.8–3.7 mm. long; enclosed pharyngeal skeleton and mouth hook as illustrated for third instar; pupa at first light, becoming dark gray before emergence.

Mines of *H. ascita* in thin submerged leaves are equally visible from

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[4]Some doubt may remain concerning the identity of these specimens, which were obtained after Cresson's death. I find no consistent differences between these larvae and puparia and those of the collections which yielded the types of *H. ascita*. G. C. Steyskal, who has compared the adults with paratypic specimens of *H. ascita*, concurs in this identification.

either side and quite readily found by examination of the leaves with transmitted light. The larvae seem to prefer the mesophyll of such flaccid leaves. It is possible that they mine just within the lower epidermis of the coriaceous floating leaves of *P. Oakesianus* only because of failure to find their preferred food. *Oakesianus* has no flaccid leaves, and no other species of *Potamogeton* occur in the bogs in which it was collected.

The occurrence of a miner in leaves as narrow as those of *P. foliosus*, which average about 1.0 mm. wide in Sodon Lake, seems quite remarkable. The mine of a mature *H. ascita* larva usually occupies the entire width of the leaf. Since all mesophyll tissue is removed and only a sheath of thin epidermis remains, the mined leaf often shreds and disintegrates even before the puparium which was formed within it can produce an adult fly. Probably the puparia found floating unattached in the lake had been anchored only by insertion of respiratory spines into the leaf midrib, and were liberated by disintegration of the entire leaf.

If the pupae within are well matured before detachment of the puparia they may yield adult flies. However, most puparia float with respiratory spines below the surface film. I found in the laboratory that, unless emergence occurs in a day or two, detached puparia usually fill with water and sink.

Most *H. ascita* larvae which live in leaves of *P. foliosus* avoid the danger of detachment by a maneuver never observed and evidently unnecessary for larvae living in the other food plants listed. These mine down to the leaf base, turn about, and insert their respiratory spines into the stem before pupation. More than 95 per cent of the puparia observed were in this position. Puparia thus anchored usually remain attached even when the leaves which originally enclosed them disintegrate. In Sodon Lake, it was not uncommon to find three or four puparia projecting nakedly into the water from a stem of *P. foliosus* six or eight inches long.

Although their positions might suggest that these puparia were formed by stem-mining larvae which had projected their anterior ends from the mines before pupation, there is good evidence to the contrary. While larvae of all three instars were found mining in leaves, neither larvae nor larval mines were observed in stems. Puparia were invariably located at nodes. Some young ones were completely enclosed in leaf epidermis, and shreds of epidermis still adhered to many older puparia.

Like other *Hydrellia* discussed here, this species seems to have no clearly defined emergence heights. Larvae and puparia were collected in Cheboygan County during the last half of July and first half of August in 1946 and in Oakland County throughout both of these months in 1949.

H. ascita is parasitized by 2 species of Braconidae, *Chorebidella* sp. and *Dacnusa* sp. 3, and by the diapriid *Trichopria columbiana*.

Hydrellia caliginosa Cresson

Hydrellia caliginosa was described (Cresson 1936) from specimens collected on the yellow water-lily in Maine. The only published ref-

erence to the biology of this species appears to be that of Cresson (1944), who wrote, "A rare species from Maine and Michigan. It is associated with spatter dock and pondweed." While not so stated, it seems probable that the latter record is based upon a single specimen reared in this study and sent to Cresson for identification on October 27, 1941.

The puparium of the specimen referred to above was extracted from a mine in a leaf of *P. praelongus* taken at Ocqueoc Lake, Presque Isle County, Michigan, on July 13, 1941. Since this specimen is the only *H. caliginosa* among the hundreds of *Hydrellia* encountered during this study, it appears that the species either is rare in Michigan or that it normally infests some other plant.

No further information was obtained concerning the biology of this species. Neither egg nor larva was observed.

Puparium.—Transparent brown; 3.45x0.95 mm.; elongate and tapering gradually to the posterior end like those of *H. bergi* and *H. ascita*; respiratory spines terminal; dorsal setae at least in intersegmental grooves of all abdominal segments; ventral setal pattern similar to that of *H. ascita* (Pl. III, fig. 2); pharyngeal skeleton (Pl. II, fig. 6) 0.46 mm. long, shaped somewhat like that of *H. ascita* but more extensively pigmented, opaque black pigment continuous from cheliform spot back to dorsoventral fork.

Notiphila loewi Cresson (Ephydridae)

Several European authors, including Muller (1922), Varley (1937), and Hennig (1943), have contributed to knowledge of the biology and metamorphosis of *Notiphila*. It seems that larvae and pupae of most species live in the soil in bottoms of lakes, ponds, and streams and have sharp, hollow terminal spines by means of which they obtain oxygen from the intercelluar gas spaces of aquatic plants.

Apparently very little is known about the immature stages of *Notiphila* in this country. From statements of Goureau (1851), Needham, Frost, and Tothill (1928) drew the general inference that the larvae are miners in leaves of plants. However, the literature shows that most *Notiphila* larvae of known habits are not leaf miners, and it may be that the genus contains no leaf-mining species. Marchal (1903), Muller (1922), and others have pointed out that the flies which Goureau reared from leaf mines in nasturtium and identified as *Notiphila flaveola* Meigen actually belong to the genus *Hydrellia*.

Johannsen (1935) omitted *Notiphila* from his key to larvae and puparia of aquatic Ephydridae and wrote, "Though the larvae of at least some members of . . . Notiphila . . . are aquatic, they either have not been described at all or have not been described in sufficient detail to be included in the above key. The eggs of Notiphila are laid on water plants."

Cresson (1944, 1946), who presented biological notes on many of the Ephydridae, discussed (1946) 21 species of *Notiphila*, but ventured no statement regarding their biology and immature stages. Concerning *N. loewi*, he write, "A relatively common species from Canada, Maine, New Hampshire, Michigan, Minnesota, Ohio, Illinois, Tennessee, Florida, Wyoming, Colorado, Utah, and Washington."

In the present study, a few larvae and many puparia of *N. loewi* were found attached to the roots of *P. alpinus* and *P. Richardsonii* in several localities in Cheboygan County, Michigan. Puparia were also found on roots of *P. pectinatus* in Cheboygan County.

Egg and immature larva were not observed.

Mature Larva (living) (Pl. IV, fig. 1).—Elongate; cylindrical, tapered toward both ends; about 8.0 by 1.2 mm.; light gray; segments not distinct; no creeping welts apparent; metapneustic with posterior spiracles in the form of slits near the tips of two hollow terminal spines; anterior end with paired, three-segmented antennae and paired inferior tubercles; pharyngeal skeleton (Pl. IV, fig. 2) composed of pharyngeal and hypostomal sclerites, colored as shown and bearing two mouth hooks; pharyngeal sclerite about 0.64 mm. long, with lateral halves connected together by anterodorsal bridge and both dorsal rods forked posteriorly.

Puparium (Pl. IV, fig. 3).—Cylindrical and tapered more gradually to posterior than to anterior end; transparent brown; 4.6–5.1x1.4–1.7 mm.; terminal respiratory spines conspicuous, about 0.18 mm. long; anal plate extending around approximately one-half the circumference of puparium, and bearing anus as midventral, longitudinal slit; enclosed pharyngeal skeleton as figured and described for larva; living pupa at first light colored, later dark brown, with red compound eyes conspicuous.

Nothing was observed to indicate that larvae of *N. loewi* feed on *Potamogeton* tissues. Form of the respiratory spines and the fact that larvae and puparia were found thus attached to roots suggest that these flies may be dependent on plants for oxygen during their larval and pupal stages. It is noteworthy that these immature stages live in black humous bottoms which are rich in decaying organic matter and practically devoid of free oxygen. Embedded in this material and thus isolated from circulating water, these insects have no apparent source of oxygen except from the roots of plants.

All attempts to rear these flies by isolating puparia together with small segments of attached roots failed, even when the pupae within were well matured in nature. If floated in water, the fine roots quickly became waterlogged, and the puparia filled with water and sank. If placed in moist atmosphere, the roots wilted, collapsed, and presumably admitted no more oxygen into the puparia. It would be difficult to transplant entire plants into screen-covered aquaria without breaking the brittle puparia or the delicate roots to which they are attached, and impossible to associate each fly which emerged in such a large container with its empty puparium. This problem was finally solved by carefully teasing all root tissue from a few puparia and placing them

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EXPLANATION OF PLATE IV

Immature stages of *Notiphila loewi* (Ephydridae). Fig. 1. Lateral view of larva. Fig. 2. Pharyngeal skeleton and mouth hooks. Fig. 3. Lateral view of puparium, attached to root. h. sc., hypostomal sclerite; p. sc., pharyngeal sclerite, showing total length; r., root of *Potamogeton.* Other abbreviations as in Plate I.
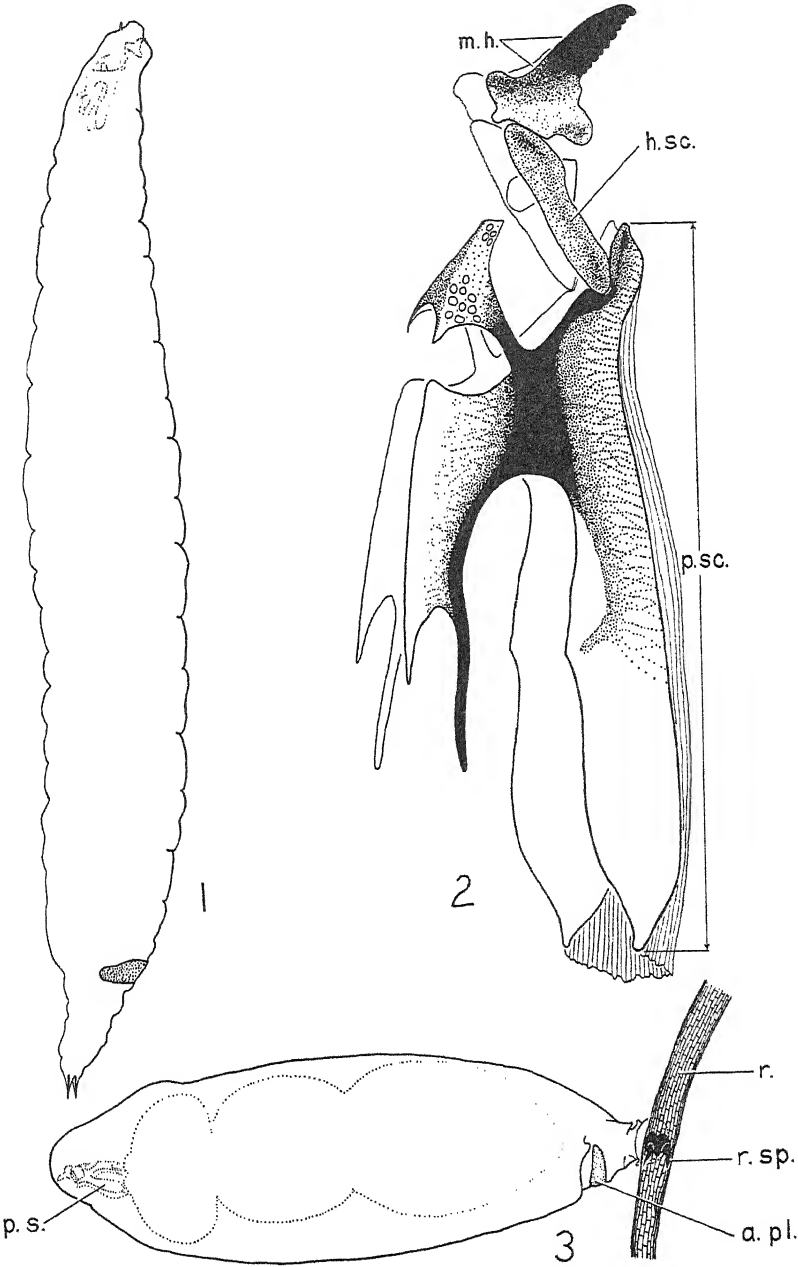
in moist sphagnum moss, each in a separate vial, with respiratory spines projecting up into the air.

Hydromyza confluens Loew (Cordyluridae)

Studies on *Hydromyza confluens* by Needham (1908) and Welch (1914, 1917) have revealed that its normal food plant is the yellow water lily. They reported that the larva lives within lily petioles, feeds on petiole tissues, and produces gall-like swellings. Pupation occurs within the cavity excavated by the larva, the puparium being completely covered by plant tissue.

A puparium which I found attached by its posterior respiratory plates to the roots of *Potamogeton alpinus* in Nigger Creek, Cheboygan County, Michigan, June 25, 1946, was detached from the root and placed on moist cotton in a rearing bottle. The freshly emerged male imago was discovered 13 days later, at 7:37 a. m. After this specimen had stroked the wings and body, stamped around, and rubbed the tarsi together for 14 minutes, the wings expanded rather suddenly. This specimen, dry and in very good condition, was killed and pinned two days later, and has been identified as *Hydromyza confluens* Loew by Fred M. Snyder, of Orlando, Florida.

Except for the posterior respiratory plates, which were covered by plant tissue, the major portion of this puparium projected into the black humus and silt of which the bottom is composed in a manner similar to that of *Notiphila loewi* (Pl. IV, fig. 3). It is evident that the respiratory plates were well embedded in plant tissue because the puparium remained attached to the root and was pulled up through the bottom soil with the plant. Under these unusual circumstances, development apparently had proceeded normally.

Summary

1. Biological data on eight species of acalyptrate flies reared from *Potamogeton* are recorded, and immature stages of seven of them are described and figured.

2. A key is presented to six species of *Hydrellia* (Ephydridae) which mine in leaves and stems of *Potamogeton*.

3. Immature stages of *Hydrellia ascita*, *H. bergi*, *H. caliginosa*, *H. cruralis*, *H. luctuosa*, and *H. pulla* are depicted, all except one of them for the first time.

4. Activities of *Hydrellia* larvae and adults, life cycles, seasonal aspects, and modes of hibernation are discussed in some detail; food plants and parasites are listed.

5. Data are presented on the biology of *Notiphila loewi* (Ephydridae), larvae and pupae of which live in humous bottoms with respiratory spines inserted in *Potamogeton* roots; descriptions and figures of immature stages are given.

6. Normal development of a *Hydromyza confluens* (Cordyluridae) pupa in the silty, humous bottom of a stream with respiratory plates embedded in a *Potamogeton* root is recorded.

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MEDICAL ENTOMOLOGY, by ROBERT MATHESON. vi+612 pages, 242 figures, 4 plates. Second edition. Comstock Publishing Company, New York. 1950. Price, $7.50.

A major handicap in the teaching of medical entomology has been the lack of a textbook which adequately presents the more recent developments in the subject. This revision of a leading prewar text by an outstanding medical entomologist will, indeed, be welcomed both by students and teachers of the subject.   The author's experience and familiarity with culicidology has aided greatly in the assimilation of the immense amount of literature which it has been necessary to review, since such an important part of that literature deals with the mosquitoes; however, his grasp of the entire, complex subject has led to the production of a textbook of high quality.

The treatment is for the most part traditional.   An introduction paves the way to an understanding of the problems involved and gives a brief historical background for understanding the Acarina, Insecta, and other more important arthropods involved in the transmission and production of human disease, after which he discusses the biologies, role in disease transmission and production, the diseases involved, and control and prophylaxis.   Veterinary aspects are included only incidentally.   In general, a taxonomic order is maintained, although the Acarina are widely separated from the poisonous Arachnida; this may not be wholly logical, since certain ticks might be discussed under both headings.   The account of Diptera, as would be expected, takes up more than half the text (pp. 218–537).   Keys and tabular material are employed freely.   A final chapter deals with collecting and preserving methods.

The book is well-written, with well-chosen illustrations which are for the most part well-executed.   One can find but little to criticize; a few things might, however, be mentioned.   The author's statement that nothing is known of the biology of *Wohlfahrtia opaca* is not correct; at least ten papers, including two by the reviewer, have been published on this subject.   The horrible illustration in fig. 186 is somewhat misleading, since in this case the screwworm attack was secondary and consequently not responsible for all the injury; a more typical illustration might have been used.   Hall's "Blowflies of North America" is omitted from the references to Chapter XVII, although the terminology of the Calliphoridae is mainly adapted from that work.   In this connection, it is noteworthy that Dr. Matheson does not recognize the generic name *Phaenicia*, although that genus is recognized as valid not only by Hall but also by such dipterists as Curran, Townsend, and Malloch.   It is only fair to say, however, that certain leading dipterists do not accept that genus.   In matters of terminology, Dr. Matheson is conservative, though sometimes inconsistent.   This conservatism is also evident in his discussion of control measures, where it is definitely desirable, in view of the rapid advances in this field which are constantly making yesterday's recommendations obsolete today.—M. T. J.

A NEW SPECIES OF ORTHOPODOMYIA FROM CALIFORNIA (Diptera, Culicidae)[1]

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The California representative of the genus *Orthopodomyia* has previously been confused with *signifera* (Coquillett), a widespread species of eastern United States west to Texas and Nebraska. Considering the geographical separation involved, it is not surprising that the Californian form has characters indicating that it is a distinct species.

Differences observed in the adults and pupae of the three United States species are minor but larval differences are well marked. The three species can be separated in the larval stage according to the following key.

KEY TO ORTHOPODOMYIA OF AMERICA NORTH OF MEXICO BASED ON FOURTH STAGE LARVAE

1. Siphon tuft less than three-fourths (0.47 to 0.68) as long as length of siphon[2] beyond insertion of tuft (fig. 2); tuft with 2 to 5 branches; lateral hair of anal segment divided from base into 2 to 4 branches, longest branch about as long as or longer (0.97 to 1.65) than length of siphon before insertion of tuft; no sclerotized plate on abdominal segment VIII; transutural hair of head (hair 9) strong and multiple..............**alba** Baker

   Siphon tuft more than three-fourths as long as length of siphon beyond insertion of tuft; tuft with more than 4 branches; lateral hair of anal segment single or divided beyond base, less than three-fourths as long as length of siphon before insertion of tuft; a sclerotized plate present on abdominal segment VIII; transutural hair weak and single, often frayed toward apex... 2

2. Siphon tuft about as long (0.81 to 1.16) as length of siphon beyond insertion of tuft (fig. 3)....................................**signifera** (Coquillett)

   Siphon tuft more nearly twice as long (1.72 to 2.26) as length of siphon beyond insertion of tuft (fig. 1)............................**californica** n. sp.

Orthopodomyia californica, new species

Female.—Length of wing 4 mm. Vertex with narrow curved white scales in median area and along eye margins, a lateral spot of broader white scales, upright forked scales numerous and black; torus with an inner patch of white scales; palpus and proboscis with numerous white scales above, latter about three times as long as former. Thoracic integument dark brown to black; scutum with many black bristles, and with three pairs of longitudinal hair-like silvery lines, outer pair extending entire length of scutum, middle pair extending forward to middle and broken halfway, inner pair extending back two-thirds of scutal length, scutellum with black bristles but devoid of scales except for a continuation of middle scutal lines; pleuron with a line of white

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[1]Cost of publication paid in part by the University of California.

[2]Length of siphon taken as greatest length of sclerotized area but excluding apical valves.

scales across anterior pronotal lobe and posterior pronotal lobe, a broad line of scales from propleuron across sternopleuron and mesepimeron, a patch on lower sternopleuron, and a few other pale scales; wing with rather broad, scattered white scales, concentrated into spots near middle of wing (on veins 4 and 5.2), at base of vein I and basal two-fifths of vein 6; halter knob pale scaled; femora and tibiae speckled black and white, tibiae lined in front; front and mid tarsi with small or indistinct, pale, joint spots, hind tarsus with distinct joint bands and all of V white above, joint band of I-II about equal in length on both segments and whole band shorter than segment IV; joint band of II-III a little shorter than segment V, joint band of III-IV about one-half as long as segment V. Abdominal segments dark with narrow pale basal bands on III to VI, II pale medially and with a lateroapical dark area, I with a medioapical pale spot; venter with basal segmental pale spots.

Male.—Palpus about as long as proboscis, a line of pale scales above on basal four-fifths of long segment, base of subterminal and all of minute terminal segment white. Antenna dark with brownish reflection.

Larval skin of type (fig. 1).—Antenna smooth, a three-branched, frayed tuft inserted at basal one-third and reaching beyond apex of shaft; clypeal spine long and slender, head hair A with 6 to 8 branches, B with 7 to 8 branches, C with 6 to 7 branches, d with 5 to 6 branches, e and f single; mentum with 17 teeth, the basal three largest. Shoulder hair 1 double, 2, 5 and 6 single, 3 triple, 4 quintuple, 7 with 7 branches; mesonotal submedian hair triple, metanotal submedian hair single. Lateral hairs of abdominal segments I and II quintuple; a small dorsal plate on VI, large ones on VII and VIII, comb with 21 teeth in upper row and 7 in lower row, other characters as shown in fig. 1. Siphon tuft a little more than twice as long as length of siphon beyond point of insertion, eight-branched (5 to 9 branches in paratypes), located slightly nearer apex in some paratypes; lateral hair of anal segment inserted at edge of plate, slender, short.

Pupal skin of type.—Apicolateral tuft of segment VII with 4 to 6 branches (3 to 8 in paratypes); apicolateral tuft of segment VIII with 9 to 10 branches (7 to 12 in paratypes); paddle hair single to double, frayed toward apex, one-seventh as long as paddle.

Type, female and its larval and pupal skins, near Sacramento at Elkhorn Ferry, Yolo Co., California, April 12, 1948, from cottonwood tree-hole (R. M. Bohart), deposited in U. S. National Museum. *Paratypes,* 65 males (22 with associated skins), 57 females (10 with associated skins), and 49 fourth-stage larvae, same data as type except that some were collected August 26, 1948, and others on November 3, 1949. Larvae were also studied from Riverside, California, May 17, 1948, from cottonwood treehole (W. C. Reeves), and Bakersfield, California, May 17, 1948, from cottonwood treehole (E. Hill).

Distribution.—The occurrence of *Orthopodomyia* in California was first noted by Ludlow (1906) who reported *"Culex* (?) *signifer"* from Benicia Barracks, Solano County. The second published record was that of Reeves (1941) who recorded the capture of large numbers of larvae and pupae from a treehole in a cottonwood in Riverside, Riverside County, and cottonwood and willow treeholes near Redlands,

1. californica

2. alba
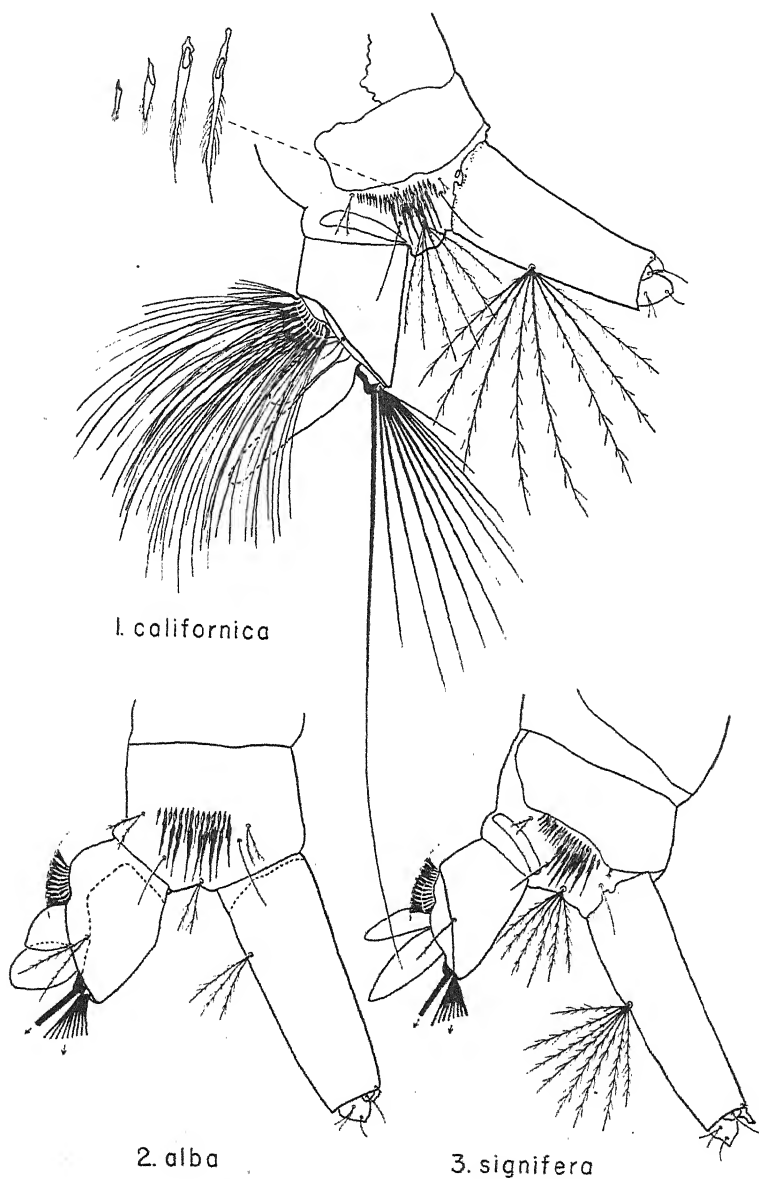
3. signifera

Terminal segments of fourth instar larvae. FIG. 1. *Orthopodomyia californica*, cast skin of type. FIG. 2. *O. alba* from Williamsburg, Virginia. FIG. 3. *O. signifera* from Williamsburg, Virginia.

San Bernardino County. Subsequently, *Orthopodomyia* have been collected either in the adult or larval stage near Bakersfield, Kern County (G. F. Smith and E. Hill), near Hanford, Kings County (Willis Wirth), at Yolo, Yolo County (E. G. Meyers), at Nice, Lake County (A. W. Lindquist), and by the writer near Elkhorn Ferry, Yolo County. It seems likely that this mosquito is widely distributed in California wherever suitable rotholes in cottonwood or willow are found.

Biology.—The Elkhorn Ferry collections were made in April, May, and August of 1948 and in November and February of 1949. Second to fourth stage larvae were taken in April and May, various larval instars and pupae in August, first to fourth instars but no pupae in November, and first to fourth instars but no second or third instars or pupae in February. From these observations it can be surmised that there are several overlapping generations through the summer and that overwintering takes place in both the fourth larval instar and the egg.

An association with cottonwood seems to be characteristic of *californica*. At the Elkhorn Ferry locality larvae of both *californica* and *Aedes varipalpus* (Coq.) were collected during April, May and August in 15 cottonwood treeholes, while in the same area 12 oak treeholes yielded only *varipalpus*. However, the specimens from Nice, cited above, were from oak treeholes.

The larvae vary in color from greenish to pink to purple presumably depending upon the amount of the pigmented bacterium, *Thiocaspa* ingested. Reeves (1940) found that pigmented larvae lost their color when changed to a yeast diet but regained the color when put back into the natural medium. It is interesting to note that the cottonwood treehole water in the Elkhorn Ferry locality has a pH of 8.0 to 8.5.

The aquatic stages of *californica* develop more slowly than any other species in the west, the nearest competitor being *Aedes squamiger* (Coquillett). First stage larvae collected on February 16, 1949, and kept in the laboratory in treehole water on a diet of powdered dog food reached the fourth instar in June, a period of about 4 months. Pupation took place late in June and the pupal stage lasted 7 to 8 days instead of the 3 or 4 days usual for most species of mosquitoes.

The ability to live for long periods on a poor diet was shown by three early fourth stage larvae which were collected August 26, 1948, and maintained in the laboratory in a glass-covered dish in diluted treehole water and no supplemental ration. One larva lived 7 months, another 8 months and the third 9 months. The first two died before pupation but the third pupated on May 26, 1949, and died 3 days later.

Systematics.—The genus *Orthopodomyia* contains about a dozen described species of essentially treehole-breeding mosquitoes from the Oriental, Holarctic, Ethiopian and Neotropical Regions. On the basis of scutal markings they can be divided into two groups, first with markings patchy, and second with longitudinal silvery lines. In the first group are *fascipes* (Coquillett) from Central and South America, *arboricollis* d'Emmerez de Charmoy from the island of Mauritius, and the Oriental species, *albipes* Leicester (type of genus), *flavithorax* Barraud, and *flavicosta* Barraud. The species with silvery scutal lines include *pulchripalpis* Rondani from Europe; *phyllozoa* (Dyar and

Knab) and *albicosta* Lutz from Central and South America; and *signifera* (Coquillett), *alba* Baker, and *californica* from the United States.

In the second group the three exotic species have characteristic wing markings which separate them from each other and from the three United States species which have a common distinctive wing pattern. *O. californica* is most closely related to *signifera*. In the adult the male genitalia appear to be identical and all other adult characters are very close. However, *signifera* specimens studied have a larger white ring over the joints between hind tarsal segments I-II and II-III, with the ring covering a greater length of I than of II and II than of III in both sexes. In *californica* the ring usually has about an equal length on I and II, and II and III in the female. The male is not always so definite in this respect. This character has been checked with U. S. National Museum specimens by Alan Stone who reports (in letter) that the difference is significant. He also remarks that in *alba* "the bands are as broad as in *signifera* but they are more evenly placed on the joint . . . " The difference is such that "it (*alba*) can be separated from *californica* without trouble, but it would be more difficult to separate it from *signifera*." Perhaps an exhaustive study of adult *alba* will reveal more definite points of distinction.

Characters of the pupa are also minor and somewhat variable. Based on 25 specimens from near Sacramento and Bakersfield, the paddle hair of *californica* is usually single but sometimes double. In either case it is frequently frayed toward the apex and may be split into several branches a short way from the base. In the eight specimens studied of *signifera* from Ames, Iowa, and New River, North Carolina, the paddle hair was rarely double, triple or sextuple, and usually quadruple or quintuple, the branches coming from the base of the hair. In two specimens supposedly of *alba* from Camp Crowder, Missouri, the paddle hair was double, triple, quintuple and sextuple, thus falling within the range of *signifera*.

In contrast with the other stages there is a marked difference between the larvae of the three United States species. This is all the more remarkable because of the similarity among larvae of several species of the genus which have obvious adult differences. Thus, *pulchripalpis* larvae are hardly separable from those of *signifera* even though the adult wing and proboscis markings are clearly distinguishing features. Both *fascipes* and *albipes*, which belong in the group with patchy adult scutum, have larvae differing only slightly from that of *signifera*. It is interesting, therefore, to find the reverse situation of almost identical adults and distinct larvae in the United States species.

In comparing the eastern species, Jenkins and Carpenter (1946) state that "It is possible that *O. alba* is a genetic variant, or that it is a well marked and distinct extreme of the natural variation of *O. signifera*." This idea, which could apply equally well to *californica*, seems unlikely in view of the stability observed in other species of the genus, and the rather small amount of variation noted within *alba* and *californica* populations.

Good series of larvae of *albipes* from the Philippine Islands and of *fascipes* from the Canal Zone were furnished by E. S. Ross of the California Academy of Sciences for a study of variation in exotic species in

comparison with domestic forms. As noted above, these two species resemble *signifera* in the larval stage. In *albipes* the siphon is more slender toward the apex and in *fascipes* the most obvious difference lies in the greater development of the thoracic hairs with the submedian mesonotal tuft many-branched rather than single. In these and other anatomical features it was found that the two species were very constant. This stability is one of shape, especially of the siphon and relative development of hairs, rather than exact number of hair branches and extent of sclerotized plates on abdominal tergites. It has been pointed out by Marshall (1938, p. 261) and Reeves (1941) that the sclerotized dorsal plates are increased in extent and number during the fourth stadium. Breland (1947) has discussed variation in *alba* and has shown that the size of the anal ring is subject to variation and may be complete, thus invalidating a character previously used in separation. However, many other relatively constant features remain for differentiation. These are discussed by Schoof and Ashton (1944).

In comparing larvae of the three United States species various characters were tabulated for the 17 available specimens of *alba* from Williamsburg, Virginia, and Camp Crowder, Missouri;[3] a like number of specimens of *signifera* taken at random from Virginia, North Carolina, Florida, Louisiana, Texas and Iowa; and 17 *californica* selected at random from Riverside, Bakersfield and near Sacramento, California. The obvious differences in the siphon and anal segment in the three species can be seen in figures 1–3. The differences and variations within species are best expressed as ratios. Thus the length of the siphon tuft divided by the siphon length posterior to insertion of the tuft averaged 0.55 (range 0.47–0.68) for *alba*, 0.96 (range 0.81–1.16) for *signifera* and 2.00 (range 1.72–2.26) for *californica*. Many additional specimens of *signifera* and *californica* were examined and found to fall respectively within the above ranges. Similarly, the length of the lateral hair of the anal segment divided by the siphon length anterior to the siphon tuft averaged 1.25 (range 0.97–1.65), for *alba*, 0.54 (range 0.35–0.67) for *signifera*, and 0.42 (range 0.33–0.61) for *californica*. The latter ratio distinguishes *alba* but not the other two species.

Institutions and individuals who cooperated by lending material were the U. S. National Museum (through Alan Stone), California Academy of Sciences (through E. S. Ross), S. F. Bailey, W. C. Reeves, and Jean Laffoon.

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[3]Camp Crowder specimens were borrowed from the U. S. National Museum.

THE WEST INDIAN SPECIES OF PHLEBOTOMUS

(Dipt. Psychodidae)

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Sandflies of the genus *Phlebotomus* are a widespread and medically important group of bloodsucking midges. Their distribution covers the tropics of both hemispheres and extends well into both the north and south temperate regions. Certain species are the vectors of various forms of leishmaniasis, of Oroya fever or verruga peruana and of pappataci or sandfly fever. Leishmaniasis in several forms is widespread in the American tropics, and verruga is known from southern Colombia to southern Peru, but neither infection has been reported from the West Indies. Sandfly fever is known with certainty only from the Old World, though cases clinically indistinguishable have been reported from a number of widely scattered places in the New World. Clinically suspicious cases have occurred in Puerto Rico, though not reported as sandfly fever because of the supposed absence of *Phlebotomus* in that area.

Previous to 1938, *Phlebotomus* sandflies were not known to occur in the West Indies outside of Trinidad. In that year Bequaert (1938) reported their occurrence in Martinique in the French West Indies, although the species has not been determined. Floch and Abonnenc (1945) were the first to determine a species from the West Indies, *P. atroclavatus* from Guadeloupe. In 1947 the junior author took *Phlebotomus* on Puerto Rico and on Vieques Island. These were described by Fairchild and Hertig (1948). In the following year Trapido again secured material from a number of widely scattered localities in Puerto Rico and from St. Thomas in the Virgin Islands which is reported on more fully below.

The discovery of these potentially important insects in the West Indies made it seem advisable to find out if they were generally distributed in the area, especially on the larger islands, and, if present, likely to become of public health significance. It was felt that the question was one of special interest to the Army, due to the strategic position of the West Indies and the previous experience of our forces with sandfly fever in the Mediterranean area. Accordingly arrangements were made for the authors to return to active duty for 30 days in order to accomplish the field work.

Field work was begun on 19 May 1949, in Jamaica, where nine days were spent. Search was made for *Phlebotomus* in approximately forty localities in eight of the thirteen parishes of the island. *Phlebotomus* were found at thirteen localities in six different parishes at elevations from sea level to about 1300 ft. Searches at higher elevations up to 4200 ft. were negative. A total of 97 specimens was taken, but at only a few places were sandflies abundant. We believe they will be found throughout the island at lower elevations, especially where suitable tree habitats occur.

The time from 28 May to 5 June was spent in Cuba. Search was made in four of the six provinces, Camaguey, Matanzas, Habana and Pinar del Rio. Because of the limited time available and the large size of the island more time was consumed in travelling and less in collecting than in Jamaica. It was impossible to visit the eastern end of Cuba, though the senior author had searched the desert area around Guantanamo Bay in 1946 without result. About twenty localities were searched in Cuba, from sea level to about 1000 ft. *Phlebotomus* was found at thirteen localities in six different parishes at elevations specimens was taken, 132 of these at one locality near Camaguey, the only time we found sandflies really abundant. At this place, Finca Chiquito Ingenio, the insects were hopping about on the trunks of mango, breadfruit and sapodilla trees in an overgrown orchard. Domestic swine shared the enclosure with chickens, turkeys and peacocks, while lizards were very abundant. Only *P. cubensis* n. sp. was taken here. At Finca El Milagro, where habitats in the form of deep buttresses and hollow trees were far more abundant, sandflies were very scarce, and we took but five specimens, two of them the new *P. orestes*, and all from the same large Ficus tree. Jointly we searched at least a hundred habitats in this patch of forest. In Western Cuba in the Vinales Valley sandflies were also scarce, a total of eight, all taken by Trapido, resulting from some 20 hours searching. They were confined to dense thickets along a stream, a single specimen here and there. Searches of limestone cavities in the sheer cliffs characteristic of this area or in the open and rather xerophytic oak-pine forests yielded nothing.

We were from 6 June to 15 June in Hispaniola, four and a half days in Haiti, and five days in the Dominican Republic. Thirty-eight localities were searched, including both north and south coasts and the highlands up to 5200 ft. elevation. Sixteen localities yielded *Phlebotomus* at elevations up to 1900 ft. A total of 162 sandflies was taken on the island, 98 in Haiti and 64 in the Dominican Republic. Near Port au Prince in buttresses of a large Ceiba tree we secured some 30

specimens, mostly females, and all of them engorged with blood. Again near Cap Haitien some 30 specimens were taken in a patch of old second growth, heavily shaded, in the narrow cracks in the trunks of logwood trees. Here too the majority of females were engorged. The ruins of King Christophe's palace of Sans Souci, at Milot near Cap Haitien and Pauline Bonaparte's old palace on the outskirts of the town yielded fair numbers of *Phlebotomus* from crevices and holes in the old masonry, the only place on the trip where we found these habitats rewarding. In the Dominican Republic our best collecting was in association with trees, either large roadside Ceibas, or shade trees in coffee or cacao plantations, but nowhere were sandflies very numerous. Our single venture into the highlands yielded nothing, though we found a fine small patch of apparently virgin deciduous forest with many suitable habitats including small animal burrows. This locality was at over 5000 ft. in mainly pine forest.

Because of the very limited time available we felt that a rapid reconnaissance of as many localities and types of habitat as possible was likely to yield the best results. For this reason we concentrated on searches of daytime resting places likely to harbor sandflies and made no attempts at trapping, light collecting, house searches or the use of animal baits. Suitable daytime resting places for these insects consist of animal burrows, hollow trees, crevices between the buttressed roots of large trees, caves and crevices in and under rocks, holes in masonry walls and, in general, small cavities which are dark and humid. Since the West Indies are extremely poor in mammals and have been very extensively deforested, we expected our best collecting to be in rock crevices and holes in masonry walls. We found, however, that the crevices between the buttressed roots of trees yielded the most sandflies. In Jamaica the large silk cotton trees (*Ceiba* sp.) are believed to be the chosen abode of "duppies," an endemic form of ghost, and are hence seldom felled. Since practically all the other large trees have long since been destroyed and the silk cotton trees, especially when old, have large buttressed roots, they proved one of the most suitable habitats for *Phlebotomus* on all three islands, but especially in Jamaica. In general, habitats associated with trees seemed the most favored, though we took sandflies in rock crevices and holes in masonry walls a number of times. Animal burrows were encountered only once, in Hispaniola, and yielded no sandflies.

Collecting was done with the aid of cigarette smoke and a suction tube. Smoke was blown into the habitat and the sandflies, if any, taken up in the suction tube as they emerged. If the hole or crevice was especially dark, a flashlight was used. The sandflies were killed in chloroform tubes and transferred to dated and numbered dry shell vials. This method of collecting has proven efficient elsewhere, and enabled us to sample a maximum of localities in a minimum time. At the same time we secured a fair number of mosquitoes which are being studied and will be reported on by our colleague Mr. Pedro Galindo.

We encountered no evidence that the species of *Phlebotomus* in the West Indies feed on man. We ourselves were not exposed, but we found no one who recognized them and no local names for them, a

condition in marked contrast to that on the mainland, where many native names occur.   It is also significant that, although many competent entomologists have visited or worked in these islands, including medical entomologists searching for biting insects, *Phlebotomus* has remained undetected until now.   Many of the females we took contained red blood, so that some vertebrate is doubtless the host, most probably lizards, as they are the most numerous terrestrial vertebrates in the West Indies and favor similar habitats.

The material collected shows the presence of two species on each of the three islands visited.   In the case of Cuba, both species appear to be new and endemic, while Hispaniola and Jamaica each have one

TABLE I

MEASUREMENTS IN MICRA

	jamaicensis		*hispaniolae*		*duppyorum*		*cubensis*		*orestes*		*christophei*	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Ant. III..............	212	196	228	164	324	240	216	172	200	168	248	216
Palpi I+II.............	140	112	112	88	156	116	148	96	128	120	160	116
Palpi III..............	136	120	120	104	168	120	140	104	124	120	144	120
Palpi IV..............	108	76	92	76	116	80	88	80	92	84	100	88
Palpi V...............	308	240	284	200	368	268	280	180	296	240	336	260
Head ht..............	204	196	220	168	208	200	220	188	220	220	260	208
Clypeus..............	124	112	128	100	120	100	120	100	120	112	148	104
Proboscis.............	220	160	160	120	180	144	172	120	172	164	240	144
Eye ht...............	148	136	136	128	144	136	168	140	132	120	168	124
Wing.................	1746	1440	1656	1224	2016	1566	1710	1350	1476	1350	1854	1458
Alpha................	468	324	450	288	504	288	378	216	216	180	450	288
Beta.......	306	252	270	180	378	306	342	252	216	198	270	198
Gamma...............	230	180	234	180	324	216	216	198	288	288	288	234
Delta.................	306	198	306	162	288	72	234	90	18	—18	162	18

peculiar species and one species probably only subspecifically distinct from the form found in Puerto Rico.   The endemic Jamaican species and one of the Cuban species belong to the same group as the Puerto Rican species, but are abundantly distinct.   The other Cuban species and the endemic Hispaniolan species are closely related to each other but belong to a quite different group from the other Antillean species. Including *atroclavatus*, there are thus three groups represented, all of which either occur on or have representatives on the mainland.   In the case of *cayennensis*, the most widespread form, there are poorly marked subspecies on Puerto Rico, Vieques, Virgin Islands, Hispaniola and Jamaica as well as in Mexico, Panama and northern South America. *P. duppyorum* n. sp. and *P. cubensis* n. sp. also belong to the *cayennensis* group, but have developed characters sufficiently marked to be considered full species.   *P. orestes* n. sp. and *P. christophei* n. sp. have close relatives in Panama and northern South America, while *P. atroclavatus* is known from Panama, Trinidad and French Guiana.

The Table of Measurements does not separate the sexes nor are means calculated, as too few specimens were available in most cases to make this of any importance. Usually the maximum figures occurred in females, the minimum in males, but no single specimen was smallest or largest in all measurements. On the whole, the measurements appear of little value in separating these species, though the long third antennal of *duppyorum* and the relatively shorter delta in *orestes* and *christophei* may be useful.

KEY TO WEST INDIAN SPECIES
Males
1. Coxite with a basal tuft of hairs... 2
   Coxite without a basal tuft of hairs; style with four major spines........... 4
2. Style with 4 major spines; basal tuft of 4 heavy setae...........**atroclavatus**
   Style with 3 major spines and an accessory subterminal seta............... 3
3. Basal tuft of numerous fine hairs borne on a salient rounded prominence; tips of genital filaments modified and expanded.................**christophei**
   Basal tuft of two groups of heavier hairs, less numerous and not borne on a prominence; tips of genital filaments little modified and hardly expanded, **orestes**
4. Cibarium with hardly visible vestiges of teeth, few in number; pharynx slender; third antennal segment longer than clypeus and proboscis.........**duppyorum**
   Cibarium with rather well marked teeth or spines; pharynx stouter; genital filaments stouter; third antennal segment considerably shorter than clypeus and proboscis.. 5
5. Cibarium with 6 spine-like horizontal teeth; no erect teeth...........**cubensis**
   Cibarium with more than six horizontal teeth and few to many erect teeth....................................**cayennensis** and subspecies

Females
1. Spermathecae with a thick, annulate common duct, the two spermathecae without individual ducts, tapering from a swollen wrinkled base to a slender tubular apex; cibarium with 4 long teeth; pharynx unarmed, **christophei**
   Spermathecae with individual ducts many times longer than the common duct, the latter slender...................................... 2
2. Heads of spermathecae pear-shaped, smooth, the ducts smooth; cibarium with 4 very small teeth; pharynx with strong transverse ridges and long spines..**atroclavatus**
   Heads of spermathecae subglobose, joining the ducts by a tapering, annulate portion; cibarium with 4 or more teeth in a comb-like row; pharynx spinose but without transverse ridges...................................... 3
3. Pharynx greatly expanded proximally, wine-glass shaped, finely spinose; cibarium with 6 to 8 short fine teeth, longest in the middle.......**duppyorum**
   Pharynx and cibarium not as above................................... 4
4. Cibarium with 4 straight teeth in a rudimentary comb; pharynx densely spinose at proximal end...................................**cubensis**
   Cibarium with 12-18 teeth in a comb-like structure; pharynx as above, **cayennensis** and subspecies

Phlebotomus christophei sp. nov.
Plate I, figs. 1 and 4; Plate II, figs. 3 and 7
Male.—A small pale sandfly without contrasting colors. Eyes relatively small, proboscis and palpi relatively long. Third antennal segment somewhat shorter than first three palpal segments. Ascoids simple, about two-thirds the length of their respective segments. Newstead's scales long and clubbed, in a large diffuse patch occupying the central third of the segment. Genitalia with three major spines

and an accessory subterminal seta, as figured. Genital pump and filaments about 1.25 times as long as coxite and style, the tips strongly modified, as figured. Cibarium without clearly visible teeth, the chitinous arch well marked but diffuse in the center. Pharynx unarmed.

Female.—External characters as in the male. Spermathecae as figured. Cibarium with four stout horizontal teeth and a number of small erect teeth below as figured. Chitinous arch high and heavily sclerotized. Pharynx unarmed. Cerci rather short and blunt.

This species is clearly related to *P. orestes*, of the present paper, from Cuba, but differs clearly in the structure of the basal tuft of the coxite as well as in other details. From the other American species of *Phlebotomus* with three spines on the style these two may be distinguished from *chassigneti* Floch and Abonnenc and *pilosus* Damasceno and Causey by the presence of well developed tufts of hairs on the base of the coxite. The species of Mangabeira's subgenus *Pressatia, P. triacanthus* and allies, are larger species, the subterminal spine of the style borne on a distinct tubercle, with an extra accessory seta on the style, and with more complex basal tufts on the coxite and more complex parameres. *P. vespertilionis* Fairchild and Hertig and *vesiciferus* F. and H. differ in having inflated lateral lobes.

Holotype male, slide 1476, 16 km. south of Hato Mayor, Prov. Seibo, Dominican Republic, 12 June 1949. In buttresses of large Ceiba tree.

Allotype female, slide 1497, Colonia San Rafael, 21 Km. south of Sabana de la Mar, Prov. Seibo, Dominican Republic, 900 ft. elev. in buttress of large tree in coffee plantation.

Paratypes, 4 males, 1 female, same data as allotype; 1 male, 1 female, Milot, nr. Cap Haitien, Haiti, 9 June 1949, in holes in wall of room in ruined palace of Sans Souci; 1 female, 34 km. south of Sabana de la Mar, Prov. Seibo, Dominican Republic, 650 ft., in buttress of large tree in coffee plantation. All Fairchild and Trapido colls. Named in honor of Christophe, King of Haiti, in whose palace the first specimens were taken.

Phlebotomus orestes sp. nov.

Plate I, fig. 2

Male.—A small pale sandfly without contrasting colors. Eyes relatively small, proboscis and palpi relatively long. Third antennal segment distinctly shorter than first three palpal segments. Ascoids simple, about half the length of their respective segments. Newstead's scales long and clubbed, in a small dense patch in the middle of the third palpal segment. Genitalia with three major spines and a subterminal seta on the style, as figured. Genital pump and filaments about one and one-half times as long as coxite and style, the tips not exserted in the available specimens, but apparently but slightly spatulate. Cibarium without visible teeth but with a well marked chitinous arch. Pharynx unarmed. Female unknown.

Holotype male and 1 male *paratype,* Finca El Milagro, between Minas and Altagracia, Camaguey Province, Cuba, 30 May 1949, Fairchild and Trapido colls. Taken in buttresses of a large tree in partly cut-over forest.
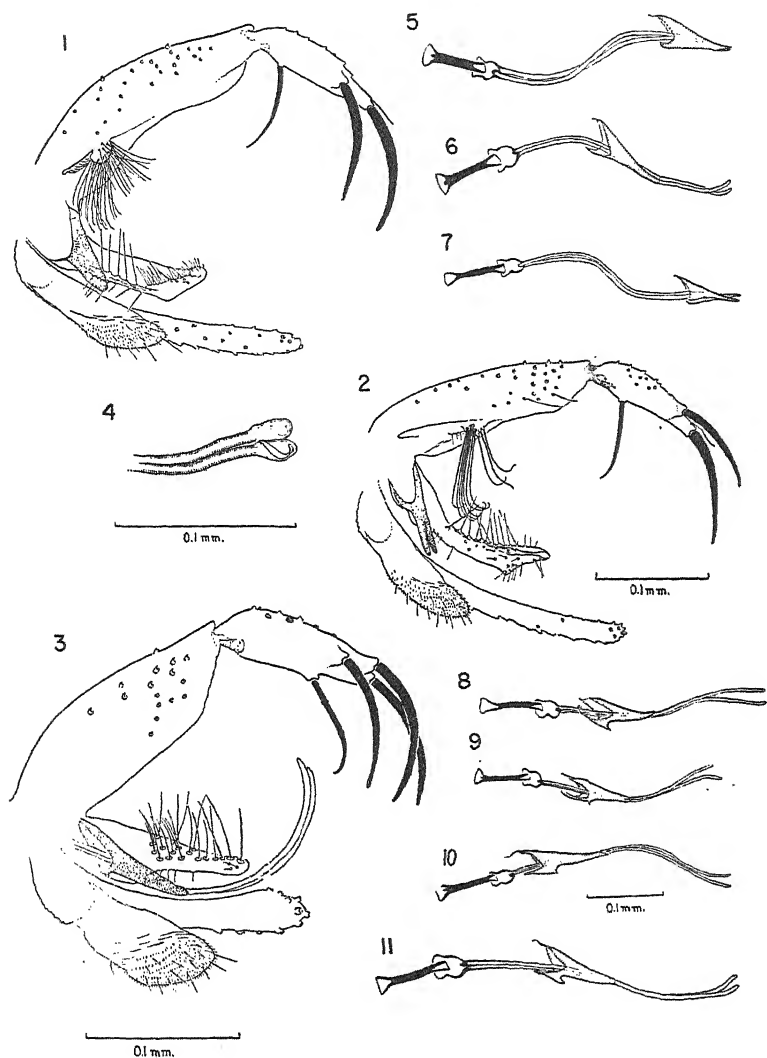
FIG. 1. *P. christophei* n. sp. Paratype, male genitalia. FIG. 2. *P. orestes* n. sp. Holotype, male genitalia. FIG. 3. *P. cubensis* n. sp. Paratype, male genitalia. FIG. 4. *P. christophei*, tips of genital filaments. FIGS. 5–11. Sperm pumps and genital filaments of: 5, *P. cayennensis viequesensis* (Virgin Islands); 6, *P. c. viequesensis* (Vieques Island); 7, *P. c. puertoricensis* (Puerto Rico), 8, *P. c. hispaniolae* n. subsp. (Dominican Republic); 9, *P. cubensis* n. sp. (Cuba); 10, *P. duppyorum* n. sp. (Jamaica); 11, *P. cayennensis jamaicensis* n. subsp. (Jamaica). Figs. 1 and 2 are to the same scale, indicated at fig. 2 and figs. 5–11 are all to the scale indicated at fig. 10.

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This species seems closely related to *P. chrristophei* of Hispaniola and to an as yet undescribed species from Panama. From *christophei* it differs chiefly in the form of the basal tuft on the coxite and in the shape of the parameres. It also appears to lack the greatly enlarged tips to the genital filaments found in *christophei*, though since these are not exserted in our two specimens, close comparison is not possible.

Phlebotomus duppyorum sp. nov.
Plate I, fig. 10; Plate II, figs. 2, 8 and 9

Male.—A small slightly dusky sandfly with erect abdominal hairs. Eyes medium sized, third antennal segment slightly longer than first three palpal segments. Ascoids simple, about one-fourth the length of their respective segments. Newstead's scales scattered along the middle third of the segment. Genitalia with four major spines, differing from *P. cayennensis* only in the more slender and relatively shorter genital filaments. Cibarium with barely perceptible vestiges of teeth, the pharynx slender, unarmed.

Female.—Externally like male, size slightly larger. Spermathecae as in *P. cayennensis*. Cibarium with 6 to 8 small teeth, longest in the middle, as figured. Pharynx greatly expanded proximally, wine-glass shaped, the proximal portion beset with numerous fine spines arranged in even diagonal rows.

Holotype, female, slide No. 1504, Ferry River, nr. Kingston, St. Andrew, Jamaica, 23 May 1949, in hole in root of tree near cave.

Allotype, male, slide No. 1500, Tom Cringle's tree, near Ferry River, Kingston, Jamaica, 21 May 1949, in deep buttresses of very large Ceiba tree.

Paratypes (mounted), 2 males, 2 females, slides 1429–1432, Spring-vale, St. Catherine, 21 May, in small cave under large boulder; 1 male, slide 1434, Springvale, St. James, 26 May, 700 ft., in buttress of Ceiba tree; 1 female, slide 1433, Schaw Castle, nr. Springvale, St. James, 26 May, 1250 ft., in buttress of *Ficus* sp. in scrubby forest; 1 male, slide 1481, Rockfort, nr. Kingston, St. Andrew, 20 May, in hole under roots of Ceiba tree; 1 male, 1 female, slides 1501, 1502, Montego Bay, St. James, 1 mi. out on Irwin road, 26 May, in buttresses of Ceiba tree; (unmounted, but examined in phenol and dried on strips of paper in vials) 2 males, same data as slide 1429; 2 males, Stony Hill, St. Andrew, 22 May, 1300 ft., in buttresses of Ceiba tree; 1 male, nr. Albion, St. Thomas, 24 May, in crevices in trunk of large *Ficus* tree; 26 males, 23 females, Melrose Hill, nr. Williams Field, Manchester, 1200 ft., 25 May, in hollows in and under roots of small tree and in buttresses of Ceiba tree; 15 males, 2 females, same data as slide 1501; 8 males, 3 females, Dee Side, Trelawney, 26 May, 350 ft., in buttresses of Ceiba tree.

This species is impossible to distinguish from the other Jamaican form without clearing and microscopic examination. The relatively longer third antennal segment is the only external character we have found to differentiate the two. The pharynx, is, however, quite unique among American *Phlebotomus*, being closely similar to such species as *P. theodori* of Palestine which Theodor (1948) places in the genus *Sergentomyia*. The male genitalia differ from *cayennensis jamaicensis* in having the genital pump smaller and the filaments shorter and considerably more
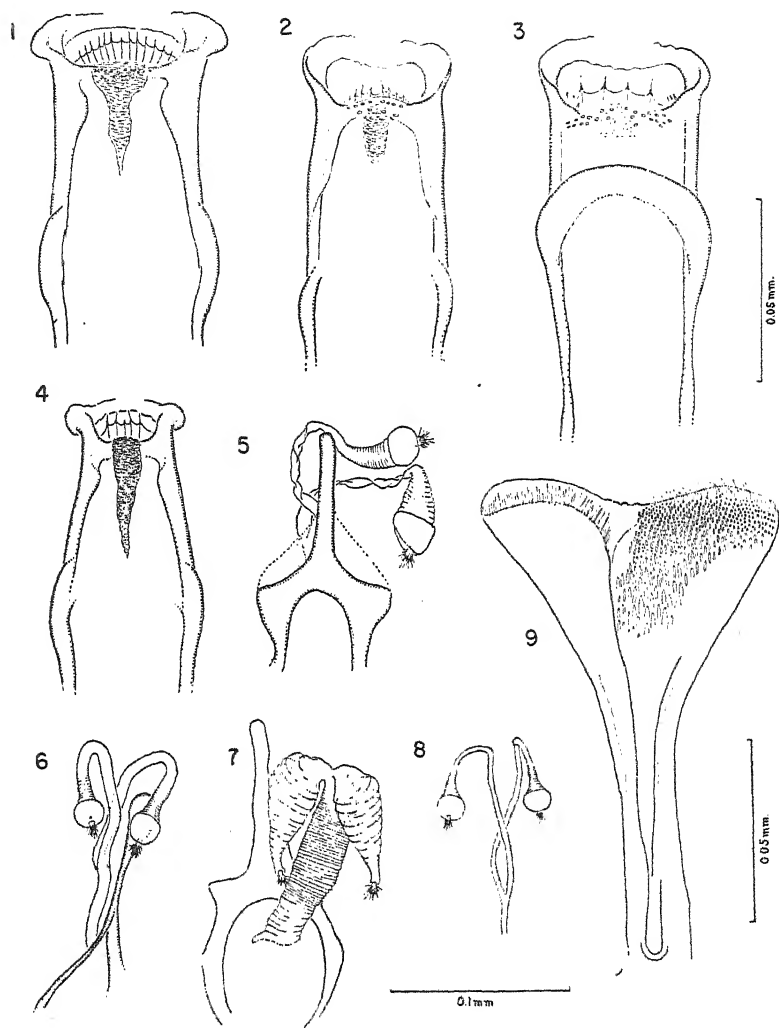
FIGS. 1–4. Female cibaria of: 1, *P. cayennensis hispaniolae* n. subsp. (Dominican Republic); 2, *P. duppyorum* n. sp. (Jamaica); 3, *P. christophei* n. sp. (Haiti); 4, *P. cubensis* n. sp. (Cuba). FIGS. 5–8. Spermathecae of: 5, *P. cayennensis jamaicensis* n. subsp. (Jamaica); 6, *P. cayennensis hispaniolae* n. subsp. (Dominican Republic); 7, *P. christophei* (Haiti); 8, *P. duppyorum* n. sp. (Jamaica). FIG. 9. Pharynx of *P. duppyorum*. Figs. 1–4 are to the scale indicated to the right of fig. 3; figs. 5–8 by the scale below fig. 8. The figures of spermathecae were drawn from specimens cleared in phenol with the exception of fig. 5 which was mounted in balsam before drawing.

slender. The male pharynx of *duppyorum* is more slender and the cibarium shows but faint vestiges of teeth, while the cibarium of *cayennensis jamaicensis* shows well marked teeth. The somewhat barbarous name was chosen to commemorate the species' marked preference for Ceiba trees, believed in Jamaica to be also the favorite domicile of "duppies," or ghosts.

Phlebotomus cubensis sp. nov.
Plate I, figs. 3 and 9; Plate II, fig. 4

Male.—A small brownish sandfly with brown mesonotum and dusky wings. Abdominal hairs mixed erect and semi-recumbent. Eyes of moderate size. Third antennal segment slightly shorter than first three palpal segments. Ascoids simple, short, hardly one-fourth the length of their respective segments. Newstead's scales slender, clubbed, in a rather dense patch on the proximal third of the segment. Genitalia as in *cayennensis*, but the genital pump and filaments smaller and shorter than in any of the forms of that species. Cibarium with apparently six or seven short teeth. Pharynx with very minute teeth in groups.

Female.—Externally like the male, but larger. Spermathecae as in *cayennensis*. Cibarium with five teeth in a rudimentary comb, the middle tooth shorter than the others, and with vestiges of another pair of teeth laterally. Pharynx densely spinose, as in *cayennensis*.

Holotype, female, slide no. 1466, Finca Chiquito Ingenio, about 10 mi. East of Camaguey, Cuba, 30 May, 1949, in shallow buttresses of trees in orchard.

Allotype, male, slide 1464, same data as holotype.

Paratypes (mounted), 2 males, 1 female, slides 1465, 1467, 1468, same data as holotype; 1 female, slide 1436, Siete Palmas, 5 mi. South of Camaguey on Carretera Vertientes, 30 May, in crevices in trunk of *Ficus* tree in pasture; 1 male, slide 1437, San Vicente, Vinales valley, 1000 ft., Pinar del Rio, 3 June, in buttress of small tree in dense thickets along stream; (unmounted but examined in phenol and dried on strips of paper in vials) 127 males and females, same data as holotype; 6 males, 2 females, same locality, but from hollow dead tree; 2 males, 1 female, Finca el Milagro, between Minas and Altagracia on Nuevitas road north of Camaguey, 30 May, in buttresses and hollow trees in cut-over forest; 2 males, 1 female, Chapaste, Havana, Prov., 2 June, in crevices in trunk of *Ficus* tree; 14 males, 4 females, 7 km. west of Ceiba Mocha, Matanzas Prov., 2 June, in buttresses of large Ceiba trees in scrubby forest; 6 males, 2 females, same locality as slide 1437 but 4 June.

Phlebotomus cayennensis jamaicensis, subsp. nov.
Plate I, fig. 11; Plate II, fig. 5

Male.—A small, somewhat dusky sandfly, the degree of infuscation of wings and mesonotum varying somewhat. Third antennal segment slightly shorter than first three palpal segments. Newstead's scales few, in a loose patch near the proximal third of the segment. Ascoids simple, short, about one-fifth length of their respective segments. Genitalia as in other races of *cayennensis*, but the pump and genital

filaments heavier and longer than in any of the others, being most closely approached by *viequesensis* in this respect.   Cibarium with a well marked comb of short but distinct teeth, 12 to 15 in number. Pharynx unarmed.

Female.—Like the male externally and in color, third antennal segment relatively shorter than in male.   Newstead's scales more numerous and in a denser patch.   Spermathecae somewhat collapsed in the single available specimen, rather large, equalling or exceeding those of *viequesensis* in size.   Cibarium with a comb of 13 to 15 long horizontal teeth and apparently four erect teeth in the middle.   This structure differs from the cibarium of *viequesensis* apparently only in having the teeth rather heavier and longer.   Pharynx rather heavily sclerotized, densely spinose at apex.

Holotype, female, slide 1480, Rockfort, nr. Kingston, St. Andrew, Jamaica, 20 May 1949; in hole under Ceiba tree.

Allotype male, slide 1479, same data as holotype.

Paratypes, 1 male, slide 1435, same locality and date as holotype, but in a shallow cave in side of quarry a few yards from Ceiba tree; 1 male, slide 1503, Ferry River, nr. Kingston, St. Andrew, Jamaica, 23 May, 1949, in crevices in rock near entrance to a large shallow cave.

This form is exceedingly close to *cayennensis viequesensis*, but appears to be larger.   Additional material will be needed to be certain that the small differences noted are really significant.   It appears to be rare in Jamaica, where it was found only in the immediate vicinity of Kingston, and may represent a rather recent importation, perhaps from one of the lesser Antilles.

Phlebotomus cayennensis hispaniolae subsp. nov.
Plate I, fig. 8; Plate II, figs. 1 and 6

Male.—A small, rather dark, sandfly with dusky wings.   The mesonotum is quite blackish, contrasting with the paler pleura.   Abdomen dusky, as are the tibiae, abdominal hairs mostly erect or semi-erect. Third antennal segment a little shorter than first three palpal segments.   Newstead's scales few, in a small patch on the proximal third of the segment.   Acoids simple, short, about one-fifth of their respective segments.   Cibarium with a comb of 8 to 10 teeth, unusually long and well developed for a male.   Pharynx apparently unarmed.   Genitalia as in other races of the species, the pump and filaments indistinguishable from those of *cayennensis puertoricensis*.

Female.—Coloration, etc., as in the male, but about one-third larger throughout.   Cibarium with 12 to 15 teeth, like *puertoricensis*, but the teeth apparently somewhat shorter.   Pharynx spinose proximally. Spermathecae with moderate sized heads but unusually thick and short ducts, much shorter and thicker than those of *puertoricensis*.

Holotype, female, slide 1478, 16 km. South of Hato Mayor, Prov. Seibo, Dominican Republic, 12 June 1949, in buttresses of large Ceiba tree.

Allotype, male, slide 1472, 34 km. South of Sabana de la Mar, Prov. Seibo, Dominican Republic, 12 June, 1949, in buttresses of large tree in coffee plantation.

Paratypes (mounted) 1 male, 2 females, same data as allotype, slides 1473, 1470, 1471; 1 female, same data as holotype, slide 1477; 1 female, 13 km. N. W. of Ciudad Trujillo, Dominican Republic, 11 June 1949, in small hollow tree in pasture, slide 1441; 1 male, Milot, nr. Cap Haitien, Haiti, 9 June 1949, in hole in ruins, slide 1439; (unmounted, but examined in phenol and placed on slips of paper in vials) 8 males, 21 females, 19 km. West of Port au Prince on Leogane road, Haiti, 7 June 1949, in buttresses of large Ceiba trees; 12 females, 19 males, Charrier, 2 km. from Cap Haitien on Limbe road, Haiti, 8 June 1949, in buttresses and holes in logwood trees in small patch of forest; 6 males, 3 females, La Voute, 4.8 miles from Cap Haitien on Limbe road, Haiti, 9 June 1949, in buttresses of door yard trees; 3 males, 2 females, Cap Haitien, Haiti, 9 June 1949, in holes in ruins of Pauline Bonaparte's palace on point East of town; 5 males, 7 females, Milot, nr. Cap Haitien, Haiti, 9 June 1949, 400 ft., in holes in ruins of palace of Sans Souci; 1 male, 2 females, 15 km. South of Cap Haitien on Milot road Haiti, 9 June 1949, in large hollow Calabash tree; 10 males, 1 female, 16 km. South of Hato Mayor, Prov. Seibo, Dominican republic, 12 June 1949, in buttresses of Ceiba tree; 14 males, 8 females, 34 km. South of Sabana de la Mar, Prov. Seibo, Dominican Republic, 650 ft., 12 June 1949, in buttresses and under loose bark of large trees in coffee plantation; 1 female, 6 km. South of Sabana de la Mar, Prov. Seibo, Dominican Republic, 12 June 1949, in buttresses of large trees in Cacao plantation; 2 males, 2 females, Rincon, between Monsenor Nouel and La Vega, Prov. de la Vega, Dominican Republic, 13 June 1949, in hollow mango tree in old cacao plantation, 500 ft.; 2 males, Rio Verde, 12 km. South of Moca, Prov. Espaillat, Dominican Republic, 14 June 1949, in buttresses of large Ceiba tree on river bank; 4 males, 2 females, nr. Colonia Pedro Garcia, between Santiago and Puerto Plata, Prov. Puerto Plata, Dominican Republic, 14 June 1949, 1900 ft., between roots of large *Cecropia* tree in secondary forest.

This race differs from the Puerto Rican form mainly in the structure of the spermathecae, the minor differences in cibarium, etc., being possibly not significant.

Phlebotomus cayennensis puertoricensis Fairchild and Hertig

1948. Ann. Ent. Soc. Amer., 41: 462.

In addition to the material previously reported (1948), we now have specimens from the following localities in Puerto Rico, collected by the junior author.

Eleven males, 2 females, Toro Negro Unit of Caribbean National Forest, near Kilometre post 47 on Route 11, northwest of Villalba, 2200 ft., 23 Sept. 1948, taken from holes and crevices among roots in roadside bank. (This is the highest elevation at which *Phlebotomus* were taken in Puerto Rico, though searched for up to 3200 ft. in the Luquillo Unit of the National Forest); 3 females, near Kilometre post 67 on Route 1, between Cayey and Aibonito, 1000 ft., 21 Sept. 1948; 2 males, 5.8 miles south of Canovanas on Route 43, 650 ft., 25 Sept. 1948, taken from a large crevice between boulders near a small stream.

Phlebotomus cayennensis viequesensis Fairchild and Hertig

1948. Ann. Ent. Soc. Amer., 41: 464.

As previously noted, the junior author took this form in some numbers on St. Thomas in the Virgin Islands. All the material was taken from drainage holes in stone retaining walls in and near the town of Charlotte Amalie between 18 and 19 Sept. 1948. Collecting was difficult, as the constant strong trade winds blew the sandflies away as soon as they were driven to the entrances of the holes by tobacco smoke.

Seven males, 6 females, Denmark Hill, 19 Sept.; 1 male, Catherine Berg 88, 19 Sept.; 7 males, 9 females, Queen's Quarters, Bjerge Gade, 18 Sept.

Phlebotomus atroclavatus Knab

1913. Ins. Ins. Mens 1: 135; Fairchild and Hertig, 1948, Ann. Ent. Soc. Amer., 41: 455.

Through the kindness of Dr. Harry D. Pratt, of the U. S. Public Health Service, we have been enabled to examine two males of this species taken by Kohler near Mt. Washington, N. W. St. Croix, Virgin Islands, 21 Sept. 1949. This extends considerably the range of this species in the West Indies, as it was hitherto known with certainty only from Guadeloupe in the French West Indies.

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Theodor, O. 1948. Classification of the Old World species of the subfamily *Phlebotominae.* Bull. Ent. Res., 39 (1): 110, Pl. XI, fig. 2.

UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES

(Diptera: Tipulidae)

PART VII

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The initial part of this series of papers was published in the Annals of the Entomological Society of America, 12 : 327–348, 1919; the preceding part in the Annals, 40 : 350–371, 1947. In the present report I am construing the limits of the paper as including the former Japanese Empire and am discussing species not only from the main islands of Japan but also from Manchuria, Korea and Formosa. Except where indicated to the contrary the types of the new species are preserved in my personal collection of crane-flies.

For a discussion of conditions in northern Korea where very extensive series of crane-flies were taken by Mr. Alexander M. Yankovsky between 1937 and 1940, a paper by the writer should be consulted.[1] For the itinerary of the Japanese expedition to Manchuria, including Jehol, the report by Tokunaga[2] may be consulted.

Genus **Tipula** Linnaeus

Tipula (Yamatotipula) nigrolamina n. sp.

General coloration gray, the praescutum with four inconspicuous darker gray stripes that are faintly margined with darker; nasus lacking; flagellar segments incised; wings with a brownish yellow tinge, only slightly variegated; stigma oval, brown; Rs about two and one-half times m-cu; male hypopygium with the tergite transverse, the caudal margin produced into two conspicuous obtuse lobes that are provided with black setae; gonapophyses with unusually short stems, the large blades blackened.

Male.—Length, about 15 mm.; wing, 17.5 mm.; antenna, about 4.1 mm.

Frontal prolongation of head relatively long, subequal to remainder of head, black, heavily pruinose, especially on dorsum; nasus lacking; palpi black. Antennae with scape brownish black, pruinose; pedicel dark brown, flagellum black; flagellar segments relatively short, conspicuously incised; longest verticils about as long as the segments; terminal segment nearly one-half as long as the penultimate, slender.

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[1]Alexander, Charles P. 1945. Undescribed species of crane-flies from northern Korea (Diptera, Tipuloidea). Trans. R. Ent. Soc. London, 95: 227–246.

[2]Tokunaga, Shigeyasu. 1934. Natural science research of the first scientific expedition to Manchoukuo. Sect. 1: 1–76, 391 figs., map; itinerary in English, pp. 45–76.

Head light gray; vertical tubercle developed as a tiny conical pro-
tuberance; anterior vertex broad, nearly five times the diameter of scape,
the eyes correspondingly small.

Pronotal scutum gray, weakly infuscated medially; scutellum and
pretergites yellow.   Mesonotal praescutum light gray, with four darker
gray stripes that are very inconspicuous against the ground; a capillary
dark brown median vitta, the remaining darkened borders less con-
spicuous but evident; praescutal interspaces very inconspicuous; scutum
gray, the lobes with scarcely darkened rings; scutellum gray, variegated
with three pale lines, including a median dash; mediotergite clearer
gray; pleurotergite gray, the katapleurotergite more yellowed.   Pleura
gray, the dorsopleural membrane broadly yellow.   Halteres with stem
obscure yellow, base of knob weakly darkened, the apex again pale.
Legs with the coxae light gray; trochanters yellow; femora obscure
yellow, the tips very gradually more blackened; tibiae brownish black;
tarsi black; claws long, with conspicuous tooth.   Wings with a brownish
yellow tinge, the cells beyond cord a trifle more darkened; prearcular
field and cell *Sc* clearer yellow; stigma oval, brown, its proximal portion
somewhat more yellowed; cells beyond stigma a trifle more whitened;
obliterative area across cell *1st* M_2 poorly indicated; veins brown, yellow
in the flavous fields.   Macrotrichia of veins beyond cord conspicuous
and relatively abundant.   Venation: *Rs* long and nearly straight, about
two and one-half times the oblique *m-cu*; R_{1+2} entire; petiole of cell M_1
subequal to *m*; *m-cu* on M_4 shortly beyond origin of latter.

Abdomen with first tergite dark gray, bordered by yellow; succeed-
ing tergites reddish, with indications of two broken stripes, these very
faint and poorly indicated on the more proximal segments, becoming
distinct on about the fifth segment; lateral borders of tergites broadly,
the caudal margins more narrowly yellow; basal sternites yellow, the
outer segments darker and more pruinose; outer segments, including
hypopygium, conspicuously blackened.   Male hypopygium with the
tergite transverse, the caudal margin produced into two conspicuous
obtuse lobes that are separated by a smaller rounded notch; vestiture
of lobes appearing as abundant long black setae but without spines.
Basistyle rather strongly produced caudad so that its apex lies almost as
far distad as does the apex of the ninth tergite.   Outer dististyle arcu-
ated, dusky, gradually narrowed to the slender obtuse tip.   Inner
dististyle without conspicuous spines, as in *ompoensis* and some other
species, generally triangular in outline, the rostral portion narrowed, its
ventral margin produced into a low lobe or flange, with a small
blackened point immediately beneath it; no developed outer basal
lobe, its position heavily blackened and thickened but not pro-
duced.   Ninth sternite with the median region broadly membranous
behind and bearing a transverse flattened hairy lobe.   Gonapophysis
appearing as an unusually large blackened blade, more or less mitten-
shaped, with the basal stem unusually short.   Eighth sternite unarmed.

Habitat: Northern Korea.   *Holotype,* ♂, Seren Mountains, altitude
3000 feet, June 26, 1938 (Yankovsky).

Other generally similar species in Japan and Korea include *Tipula
(Yamatotipula) kamikochiensis* Alexander, *T. (Y.) machidai* Alexander,
T. (Y.) ompoensis Alexander, and *T. (Y.) sempiterna* Alexander.   The

present fly differs very conspicuously in the structure of the male hypopygium, especially the tergite, inner dististyle and gonapophysis.

Tipula (Arctotipula) conjuncta conjunctoides n. subsp.

Male.—Length, about 20 mm.; wing, 19 mm.; antenna, about 6 mm. Described from an alcoholic specimen.

Characters as in typical *conjuncta*, differing as follows:

Antennae weakly bicolored, the extreme proximal end of each segment obscure yellow, the remainder dark; distal end of individual flagellar segments not produced, the outer end being narrower than the basal enlargement (compare typical *conjuncta* Alexander, 1925 Encycl. Entomol., Diptera, 2 : 88–89, fig. 2, antenna, and fig. 3, venation).

General coloration of thorax (in alcohol) dark gray, the abdomen chiefly obscure yellow. Legs longer and more slender than in typical *conjuncta*, this probably a sexual character. Wing pattern almost exactly as in *conjuncta*, the veins a little darker. Macrotrichia of veins lacking or virtually so on Rs and its anterior branch, abundant on distal end of vein R_{4+5} and on distal ends of outer medial branches. Venation: Cell R_3 with inner end more pointed, cell R_2 at margin being correspondingly widened, about one-half as extensive as cell R_3; inner end of cell *1st* M_2 less pointed; cell M_1 much deeper, approximately three times its petiole.

Male hypopygium large and powerfully constructed. Ninth tergite extensive, depressed, the caudal margin with a deep, parallel-sided median notch, the very broad lateral lobes truncated at apex, the outer lateral portion rounded; dorsal surface of tergite with abundant short dense setae. Inner dististyle produced into a very long slender simple beak; entire outer surface of style with coarse setae. Eighth sternite unarmed, without lobes or hair-pencils.

Habitat: Manchuria (Jehol).

Holotype, alcoholic ♂, No. 25, without more specific data. See reference to the Manchoukuo Expedition in introduction to this paper.

Typical *conjuncta* is still known only from the Ussuri District, eastern Siberia. In its general appearance the present fly is very similar and I would have considered the two as being identical if it were not for the structure of the antennae and the venation. In size, and in coloration of the body and wings, the two flies are very similar to one another. They may be separated by the following key:

1. Flagellar segments with outer end slightly produced to form a weak serration; cell M_1 of wings shallow, shorter than its petiole.......**conjuncta conjuncta**
   Flagellar segments widest at the basal enlargement, the distal end narrow; cell M_1 deep, approximately three times its petiole..**conjuncta conjunctoides**

The subgeneric position of *conjuncta* had been held in question (Alexander, Philippine Journ. Sci., 1935, 57 : 85) but its reference to *Arctotipula* Alexander now seems fully justified since the general structure of the male hypopygium is very suggestive of that of *Tipula (Arctotipula) miyadii* Alexander, of the Kurile Islands. The species is told from all other now rather numerous members of the subgenus by the fusion of veins R_{4+5} and M_{1+2}, obliterating the *r-m* crossvein.

Tipula (Arctotipula) laterodentata n. sp.

General coloration gray, the praescutum with four darker stripes that are incompletely bordered with darker brown; nasus lacking; antennae black, the more basal flagellar segments with their proximal portions brightened; femora brownish yellow, the tips blackened; claws (male) toothed; wings brownish yellow, restrictedly patterned with darker, including the blackened stigma; basal abdominal tergites reddish, with a broad black central stripe, the first tergite, sternite and outer segments more uniformly dark gray; ninth segment blackened; male hypopygium with outer angle of tergal lobe produced into an acute spine; outer dististyle conspicuously dilated at near midlength; inner dististyle at apex expanded into a blade, the rostral portion glabrous, the upper angle with powerful setae; face of style with a strong blackened spine.

Male.—Length, about 16–17 mm.; wing, 16.5–18 mm.; antenna, about 3.3–3.6 mm.

Frontal prolongation of head moderately long, dark gray, without nasus; palpi black, relatively short, especially the terminal segment. Antennae relatively short, black, the scape and pedicel gray pruinose; bases of proximal four or five flagellar segments restrictedly obscure yellow, the remainder black; flagellar segments subcylindrical, with scarcely indicated basal enlargements, the verticils exceeding the segments. Head gray, the vertex with a broad brown central stripe; eyes relatively small, anterior vertex unusually broad, nearly five times the diameter of scape.

Pronotum gray, somewhat weakly infuscated medially, the scutellum and pretergites obscure yellow. Mesonotum gray, the praescutum with four darker gray stripes, the outer borders of the intermediate pair and the inner margins of the lateral stripes darker brown; each scutal lobe with two brownish gray areas; mediotergite with a central infuscation or short stripe; vestiture of mesonotum relatively long but sparse, almost white. Pleura gray, the dorsopleural membrane buffy yellow, conspicuously variegated with dark brown. Halteres with stem yellow, knob brownish black. Legs with coxae light gray; trochanters somewhat darker gray; femora brownish yellow, the tips blackened, the amount subequal on all legs but with the posterior pair more fulvous yellow, preceding the darkened portions; tibiae black, the bases restrictedly obscure yellow; tarsi black; claws (male) with strong subbasal tooth. Wings with the ground brownish yellow, restrictedly patterned with darker; prearcular field extensively yellowed; stigma oval, conspicuously blackened; cell *Sc* weakly infuscated; cord and most of the veins beyond it insensibly seamed with darker, most evident over the posterior cord and distal ends of the outer radial cells; veins dark brown, yellow in the prearcular field. No squamal setae; veins unusually glabrous, as is common in the subgenus, beyond the cord with an extensive series over most of the outer section of R_{4+5}. Venation: R_{1+2} entire but short and oblique; Rs relatively long, about two and one-half times *m-cu;* petiole of cell M_1 subequal to *m;* cell *1st* M_2 relatively long and narrow, its inner end more or less pointed.

Basal abdominal tergite gray, the succeeding four tergites conspicuously reddened, with a broad black central stripe that is narrowly

interrupted at the posterior borders of the segments; lateral tergal borders light gray, vaguely bordered internally by more brownish gray; sternites and outer tergites gray, more or less patterned with more reddish areas; ninth segment, excepting the outer dististyle, blackened. Male hypopygium with the lateral lobes of tergite broad, truncated, separated by a deep U-shaped median notch; outer angles of lobes produced into strong chitinized points; ventral surface of mesal angles with a strong blackened chitinized blade or flange; tergite with abundant black setae, on the mesal portions even more dense and conspicuous. Outer dististyle widely dilated at near midlength, its greatest width exceeding one-half the length, the more narrowed apex obtuse. Inner dististyle moderately wide, at apex dilated into a truncated blade, the lower or rostral portion subglabrous, the upper part with about eight or nine powerful setae; face of style with a strong blackened spine.

Habitat: Northern Korea. *Holotype,* ♂, Seren Mountains, altitude 2500 feet, June 15, 1938 (Yankovsky). *Paratopotypes,* 6 ♂ ♂.

Readily told from the other regional members of the subgenus by the coloration of the body and antennae and especially by the structure of the male hypopygium, particularly the tergite and inner dististyle. The characters of the subgenus and a list of the regional species have been given by the writer in earlier papers (1933, Philippine Journ. Sci., 52 : 410–411; 1935, *idem,* 57 : 116–117). Lackschewitz (1936, Trav. Inst. Zool. Acad. Sci. URSS, 4 : 245–312) has attempted to synonymize certain of the Nearctic species of *Arctotipula* described by the writer with other common and widespread Arctic forms, specifically *Tipula (Arctotipula) aleutica* Alexander with *T. (A.) besselsi* Osten Sacken, the latter the subgenotype, and *T. (A.) alascaensis* Alexander with *T. (A.) ciliata* Lundstrom of Arctic Eurasia. I can affirm that in neither of these instances is the placing in synonymy justified and both species are entirely valid. Actually *besselsi* is very close to the commonest species in Arctic Europe, *T. (A.) salicetorum* Siebke (*nigricornis* Zetterstedt, not Macquart), both having a peculiar blackened sclerotized armature on the ventral surface of the ninth tergite. It is becoming increasingly evident that there are relatively numerous species in the Holarctic Region, some closely interrelated yet nevertheless quite distinct. Attention again may be called to the fact that the northern European *T. (A.) tumidecornis* Lundstrom and the Nearctic *T. (A.) illustris* Doane (*fuscipennis* Loew, 1865, nec Curtis, 1834) are actually species of *Arctotipula* and not members of the genus *Prionocera* Loew, where they have commonly been placed.

Tipula (Arctotipula) mediodentata n. sp.

Size large (wing, 18 mm.); general coloration gray, the praescutum with four darker brownish gray stripes; nasus elongate; antennae with pedicel obscure yellow, flagellum brownish black; femora yellow, the tips conspicuously blackened; claws (male) toothed; wings brownish yellow, weakly patterned with darker; stigma oval, dark brown, in male with about 25 trichia, glabrous in female; veins beyond cord with numerous trichia; male hypopygium with the tergite narrowed outwardly, the caudal margin with a broad but deep U-shaped median notch, the sides of lobes adjoining the notch produced caudad into

slender setuliferous points; outer dististyle greatly expanded outwardly; inner dististyle with the outer basal lobe a blackened spine, with two further smaller spines on margin; gonapophysis with abundant microscopic tubercles.

Male.—Length, about 16 mm.; wing, 18 mm.; antenna, about 4 mm.
Female.—Length, about 17 mm.; wing, 18 mm.

Frontal prolongation of head relatively short, dark gray; nasus conspicuous, nearly one-half the length of the prolongation, truncated at apex; palpi with basal three segments dark brown, the terminal one pale yellowish brown. Antennae with scape light brown, gray pruinose, pedicel obscure yellow, flagellum brownish black; flagellar segments (male) relatively short, moderately incised, with the basal enlargements becoming well-indicated on the more distal segments; terminal segment more than three-fourths the length of the penultimate; longest verticils slightly exceeding the segments in length. Head light gray, a trifle more infuscated on the broad vertex, particularly in female; vertical tubercle not or scarcely indicated; vestiture of vertex relatively long, blackened.

Pronotum infuscated medially, gray on sides; scutellum and pretergites light yellow. Mesonotum gray, the praescutum with four darker brownish gray stripes, much more distinct and contrasted in female, the stripes entire or with the mesal edges of the intermediate pair slightly more darkened; scutal lobes conspicuously patterned with brownish gray; scutellum broadly dark brown; mediotergite with a much narrower capillary brown central stripe; pleurotergite with the katapleurotergite more infuscated. Pleura gray, somewhat darker on the anepisternum, the dorsopleural membrane broadly light yellow; in female, the membrane more infuscated, especially posteriorly. Halteres obscure yellow, the base of knob restrictedly more darkened. Legs with the coxae gray, with long setae; trochanters yellow; femora yellow, the tips conspicuously blackened, the amount approximately equal on all legs; tibiae and basitarsi light brown, darker at tips, remainder of tarsi black; claws (male) toothed. Wings with a weak brownish yellow tinge, darker beyond cord; prearcular field and cell Sc more yellowed; stigma oval, dark brown, conspicuous, provided with about 25 trichia in male, glabrous in female; narrow pale brown seams on cord and outer end of vein M; veins beyond cord and the axillary border less evidently seamed with brown. Squama naked; veins beyond cord with abundant trichia, particularly in radial field, becoming more sparse in the medial field, on M_4 only at base. Venation: Rs about two and one-half times m-cu; R_{1+2} relatively short, pale and with trichia only near origin; in female, vein R_3 longer and more extended; second section of M_{1+2} arcuate, widening cell $1st$ M_2; m about twice the petiole of cell M_1.

Abdomen of male with basal tergite gray, with a brown central spot; succeeding tergites yellow with a broad brownish black median stripe that is broadly interrupted by the yellow posterior borders of the segments, lateral tergal borders paling to gray; sternites gray, the caudal borders narrowly yellow; outer segments, including hypopygium, more uniformly blackened, the outer dististyle conspicuously yellow. In the female, the abdomen is somewhat the same but the gray lateral tergal borders are margined internally by somewhat paler brown, not forming

a distinct sublateral stripe; pleural membrane dark. Ovipositor with
the genital shield and the preceding segment dark brown; cerci com-
pressed, yellow, the margins smooth; hypovalvae much deeper, their
tips truncated. Male hypopygium with the tergite large, the basal
third glabrous, the outer portion with dense black setae; outer and
narrowed to give a general convex appearance to the distal portion, the
median region with a deep and broad U-shaped notch; sides of notch
produced caudad into slender yellow points that are densely setuliferous.
Outer dististyle greatly expanded at outer end, appearing generally
triangular in outline, the width across the truncated apex exceeding
two-thirds the length of the style. Inner dististyle elongate, strongly
bent at near midlength; beak more or less truncate, its sides with a
conspicuous blackened lateral flange back from the apex; outer basal
lobe a short but powerful blackened spine; margin of style basad of this
spine with two smaller erect spinous points. Gonapophysis widened
outwardly, the tip membranous, the surface with abundant microscopic
tubercles.

Habitat: Northern Korea. *Holotype,* ♂, Chonsani, altitude 4300
feet, July 14, 1937 (Yankovsky). *Allotopotype,* ♀, pinned with type.
Paratopotype, ♀, same data.

Although generally similar to *Tipula* (*Arctotipula*) *laterodentata*
n. sp., the present fly is entirely distinct, particularly in the nasus and
in the structure of the male hypopygium, as the tergite, both dististyles
and the gonapophysis.

Tipula (Acutipula) bicompressa n. sp.

Allied to *bipenicillata;* size large (wing, male, over 20 mm.); wings
yellowish brown, the prearcular and costal fields more yellowed; oblit-
erative band conspicuous; male hypopygium with the median lobe of
ninth tergite unusually slender; inner dististyle with the outer beak
produced into a bulbous or spatulalike lobe, with a small slender spine
near its base; eighth sternite sheathing, on either side of apical portion
with a compressed flattened lobe that is densely covered with short setae.

Male.—Length, about 20 mm.; wing, 21 mm.; antenna, about
5.1 mm.

Frontal prolongation of head blackened, sparsely pruinose above at
base; nasus elongate; palpi black, incisures restrictedly brightened;
terminal segment not exceeding twice the penultimate. Antennae of
moderate length; scape and pedicel yellow; first flagellar segment obscure
yellow, restrictedly darkened at base; succeeding segments very vaguely
bicolored, darkened at base, the stems a trifle paler; outer segments
more uniformly dark brown. Head gray; eyes large; anterior vertex
relatively narrow, only about one and one-half times the greatest
diameter of scape.

Pronotum obscure yellow. Mesonotal praescutum and scutum
more brownish gray, the former without clearly defined stripes; scu-
tellum and postnotum more yellow pollinose. Pleura, including dorso-
pleural membrane, uniformly yellow. Halteres with stem yellow, knob
infuscated. Legs with the coxae and trochanters yellow; remainder of
legs elongate; femora and tibiae obscure yellow; the tips very narrowly and
inconspicuously darkened; tarsi brown, the outer segments passing into
black; claws (male) toothed. Wings with a strong yellowish brown

tinge, the prearcular and costal fields clearer yellow; stigma oval, darker brown; obliterative band along cord conspicuous, entering the base of cell M_3; veins dark brown, more yellowed in the brightened fields. Squama with trichia; veins beyond cord without trichia, excepting a restricted series along vein R_{4+5}.   Venation: R_{1+2} entire; cell R_2 narrowed at base; m a little exceeding the petiole of cell M_1; m-cu a short distance before the fork of M_{3+4}.

Abdomen with basal tergites obscure yellow, the outer ones somewhat more darkened medially; caudal borders of tergites very narrowly, the lateral margins more broadly pale yellow; basal sternites yellow; outer segments passing into black. Male hypopygium with the ninth tergite produced into an unusually slender lobe, the tip entire, densely set with short blackened spines. Outer dististyle relatively small, widest at near midlength, the tip obtuse. Inner dististyle small; beak small and slender, outer beak produced into a bulbous or spatulate lobe, its lower margin further produced into an obtuse flange; between the two beaks with a small straight spine; outer margin of style with abundant erect setae. Eighth sternite sheathing, on either side of the apical portion with a conspicuous longitudinal compressed-flattened lobe that is densely covered with short setae; median space between lobes wide, filled with pale membrane.

Habitat: Northern Korea. *Holotype*, ♂, Puksu Pyaksan, altitude 2500 feet, June 8, 1939 (Yankovsky).

Tipula (Acutipula) bicompressa is most similar to *T. (A.) bipenicillata* Alexander and *T. (A.) tokionis* Alexander, differing from both particularly in the structure of the male hypopygium, including the tergite, both dististyles, and the eighth sternite.

Tipula (Lunatipula) sublimitata atrodeclivis n. subsp.

Male.—Length, about 19 mm.; wing, 19 mm.; antenna, about 6.3 mm.

Generally similar to typical *sublimitata* Alexander, of Kamtchatka, differing chiefly in the structure of the male hypopygium, as follows: Ninth tergite with the mesal faces of the tergal lobes heavily blackened and precipitous. Outer dististyle dilated into a slightly flattened blade. Inner dististyle with beak very slender; outer basal lobe a small thumblike lobe. Eighth sternite with the lateral lobes relatively short and stout, blackened, each lobe narrowed outwardly, terminating in an acute sclerotized point, the face and mesal margin with abundant long coarse setae; beneath the lateral lobes and closer to midline with a pair of smaller darkened obtusely pointed lobes. In the typical form, the lateral lobes of the eighth sternite are elongate, decussate across the midline, their tips expanded, blunt.

Habitat: Northern Korea. *Holotype*, ♂, Seren Mountains, altitude 5000 feet, August 2, 1938 (Yankovsky).

Genus **Dicranota** Zetterstedt

Dicranota (Dicranota) profunda n. sp.

General coloration of thorax brownish yellow, the pleura and posterior sclerites clearer yellow; legs brownish yellow; wings uniformly

pale yellow; R_{2+3+4} long, subequal to or exceeding m-cu; cell M_2 open; abdomen brownish yellow, the subterminal segments darkened to form a ring; male hypopygium with the tergite profoundly incised medially, the notch unusually deep and narrow, each lateral lobe further subdivided by a smaller emargination, the intermediate lobules thus formed long and slender.

Male.—Length, about 5–5.5 mm.; wing, 5.5–6 mm.

Female.—Length, about 5.5–6 mm.; wing, 6.3–7 mm.

Rostrum brownish yellow; palpi pale brown. Antennae relatively short; scape yellow, remainder of organ black. Head dark gray, paler behind.

Thorax obscure yellow or brownish yellow, the pleura and posterior sclerites of notum clearer yellow; in cases, the pronotum and praescutum a trifle darker. Halteres with stem yellow, knob weakly infuscated. Legs with the coxae and trochanters yellow; remainder of legs obscure brownish yellow, the outer segments passing into pale brown. Wings uniformly pale yellow; stigma barely indicated; veins pale brown, a little more yellowed in the basal and costal regions. Venation: Sc moderately long, Sc_1 ending about opposite the fork of R_{2+3+4}, Sc_2 shortly before midlength of the distance between arculus and origin of Rs; supernumerary crossvein in cell R_1 usually present, in cases very faint to lacking; R_{2+3+4} long, subequal to or exceeding m-cu; R_2 far distad, nearly perpendicular, longer than R_{1+2}; basal section of R_5 very reduced to lacking, Rs being in virtual alignment with the second section of the vein; cell M_2 open; m-cu opposite or before midlength of M_{3+4}.

Abdomen with tergites brownish yellow, the posterior borders clearer yellow; sternites clear yellow; subterminal segments more darkened to form a ring; styli of hypopygium obscure yellow. Male hypopygium with the tergite profoundly incised medially, the notch unusually deep and narrow, each lobe further subdivided by a smaller emargination, the intermediate lobules thus formed long and slender, jutting beyond all other parts of the tergite, obtuse at apex and tipped with a few short setae. Basistyle with interbase a broad flattened blade, irregular in outline, widest about opposite midlength, the bulging outer margin with microscopic crenulations or weak serrulations; inner margin of interbase with a short spinous point; extreme apex of basistyle short-pointed, provided with three or four stout spinous setae. Two dististyles, both elongate, the outer cylindrical, with abundant stout setae, those nearest apex stronger and subspinous; inner style about as long, its basal third a little dilated, the outer part a flattened blade with the apex obtusely rounded.

Habitat: Japan (Honshu). *Holotype*, ♂, Funakosi, Iwateken, altitude 100 meters, May 21, 1947 (H. Yamamoto). *Allotopotype*, ♀. *Paratopotypes*, 4 ♂ ♀, pinned with the types.

The most similar regional species is *Dicranota* (*Dicranota*) *nippoalpina* Alexander, of the Japanese Alps, which differs very strikingly in all details of structure of the male hypopygium. The superficially somewhat similar species of the subgenus *Rhaphidolabis*, including *D.* (*R.*) *consors* Alexander and *D.* (*R.*) *subconsors* Alexander, have entirely distinct male genitalia.

Genus **Paradelphomyia** Alexander

Paradelphomyia (**Oxyrhiza**) **nimbicolor** n. sp.

Thorax almost uniformly dark brown or brownish black; antennae short, black throughout; wings of male widest opposite the termination of vein *2nd A*, strongly suffused with dusky; male hypopygium with the dististyles terminal in position.

Male.—Length, about 5 mm.; wing, 5.3 mm.

Female.—Length, about 6.5 mm.; wing, 6.5 mm.

Rostrum and palpi black. Antennae short, black throughout; proximal two flagellar segments more or less united into a fusion segment; outer flagellar segments long-cylindrical, with long conspicuous verticils. Head black, sparsely pruinose.

Mesonotal praescutum almost uniformly dark brown or brownish black, the remainder of notum a trifle paler. Pleura brownish black. Halteres with stem weakly infuscated, narrowly paler at base, knob dark brown. Legs with coxae and trochanters testaceous; remainder of legs dark brown, the tarsi passing into black; tibial spurs distinct. Wings of male broadest opposite the termination of vein *2nd A*, strongly suffused with dusky, the stigma a little darker brown; wing base a little more yellowed, including the veins; remaining veins brown. Macrotrichia of outer cells relatively abundant, in male from cell R_1 through cell M_3, in the female even more extensive, into cell M_4. Venation: Sc_1 ending about opposite the fork of Rs, Sc_2 some distance from its tip, Sc_1 alone subequal to R_{2+3+4}; R_2 faintly indicated to lacking, when present placed at or before the fork of R_{3+4}; R_{2+3+4} in virtual longitudinal alignment with vein R_3; veins R_3 and R_4 divergent, cell R_3 at margin being nearly twice cell R_2; cell M_1 present, about one-half its petiole or slightly more; *m-cu* close to midlength of cell *1st M_2*.

Abdomen brownish black, the hypopygium a trifle paler. Male hypopygium with the dististyles terminal in position; outer style ending in two major slightly curved spines, the subterminal spine erect and nearly straight. Phallosomic region injured in the unique type slide; before this damage occurred, an elongate pale slender rod, presumably the aedeagus, was noted as being present.

Habitat: Japan (Honshu). *Holotype:* ♂, Funakosi, Iwateken, altitude 100 meters, September 26, 1947 (H. Yamamoto). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 2 ♀ ♀.

The present fly is very distinct from the other regional species in the structure of the male hypopygium, especially the terminal dististyles. In the most similar regional species, *Paradelphomyia (Oxyrhiza) ariana* (Alexander) and *P. (O.) nipponensis* (Alexander), the apex of the basistyle is produced beyond the point of origin of the dististyles as a strong spine. The European members of the subgenus likewise have the dististyles of the hypopygium terminal in position but differ from the present fly in various other regards, including coloration and venation. In its general appearance, the present fly is somewhat more like *ariana* than it is to other regional species.

Paradelphomyia (**Oxyrhiza**) **chosenica** n. sp.

Size large (wing, female, over 7 mm.); general coloration black, the

surface obscured by a gray pruinosity; halteres yellow; femora light yellow, the tips narrowly and vaguely darkened; wings brownish yellow, clearer yellow in the prearcular and costal fields; abundant macrotrichia in outer cells of wing; cell M_1 small; *m-cu* at or before midlength of cell *1st M_2*.

Female.—Length, about 8 mm.; wing, 7.5 mm.

Rostrum and palpi black. Antennae with scape, pedicel and basal segment of flagellum black, the remainder broken. Head black, opaque by a gray pruinosity; anterior vertex broad, exceeding three times the diameter of scape.

Prothorax and mesothorax black, the color obscured by a gray pruinosity, heaviest on the lateral portions of the praescutum, scutellum, postnotum and pleura; anterior lateral pretergites obscure yellow. Halteres yellow. Legs with the fore coxae black; middle coxae blackened, the tips pale; posterior coxae obscure yellow; trochanters yellow; femora light yellow, the tips narrowly and vaguely darkened; base of tibiae yellow (broken before midlength). Wings with a strong brownish yellow tinge, the prearcular and costal fields clearer yellow; stigma oval, pale brown; veins brown, clear yellow in the brightened fields. Abundant macrotrichia in apical cells of wing from Sc_2 to *1st A*, inclusive, especially numerous in radial and medial cells. Venation: Sc_1 ending about opposite fork of *Rs*, Sc_2 some distance from its tip, Sc_1 alone about three-fifths R_{2+3+4}; vein R_1 sinuous near the insertion of vein R_2; *Rs* long; R_{2+3+4} in longitudinal alignment with R_{2+3}; vein R_2 very faint to nearly obsolete, a little longer than R_{2+3}; cell M_1 small, about one-third its petiole; *m-cu* at from one-third to nearly opposite midlength of cell *1st M_2*.

Abdomen black, sparsely pruinose. Ovipositor with valves strong, yellowish horn colored.

Habitat: Northern Korea. *Holotype,* ♀, Kankyo Nando, Puksu Pyaksan, altitude 6000 feet, June 30, 1939 (Yankovsky).

The present fly is well-distinguished from all other regional members of the genus of major size. The most similar of such species is *Paradelphomyia (Oxyrhiza) majuscula* (Alexander), of western China. The present fly differs in the details of coloration and venation, as the short Sc_1, narrower cell R_3, and the unusually small cell M_1.

Genus **Archilimnophila** Alexander

Archilimnophila subunicoides n. sp.

Allied to *subunica;* antennae (male) relatively short, only about one-third as long as the wing; wings relatively narrow, restrictedly patterned with brown; male hypopygium generally as in *subunica,* the gonapophyses simple.

Male.—Length, about 9–10 mm.; wing, 9–10 mm.; antenna, about 3.2–3.3 mm.

Female.—Length, about 10–11 mm.; wing, 10.5–11 mm.

Rostrum gray; palpi brown. Antennae (male) relatively short for a member of the genus, dark brown; flagellar segments elongate, subequal to the verticils. Head gray; anterior vertex broad.

Pronotum gray, the sides of the scutellum obscure brownish yellow. Mesonotum gray, the praescutum with four more blackened stripes, the narrow intermediate pair only narrowly and incompletely separated by a gray vitta; scutal lobes weakly patterned with darker. Pleura gray, somewhat darker on the ventral sternopleurite; dorsopleural membrane buffy yellow to light brown. Halteres with stem obscure brownish yellow, knob more infuscated. Legs with the coxae yellow, more or less pruinose, the fore pair extensively more blackened, the middle pair similarly colored basally; trochanters yellow; fore femora extensively blackened, with about the proximal fourth or fifth yellow; remaining femora yellow, the tips more narrowly blackened; tibiae brownish yellow, the tips darkened; tarsi black. Wings relatively narrow, yellow, the base clearer yellow; a restricted brown pattern, including the stigma and clouds at origin of *Rs*, along cord, outer end of cell *1st M_2* and fork of M_{1+2}; veins brown, darker in the patterned portions, clear yellow at wing base. Venation: R_{2+3+4} from about one-half to nearly two-thirds the strongly decurved R_4; cell M_1 usually subequal in length to its petiole, in cases a little longer or shorter; *m-cu* at from about one-fourth to beyond one-third the length of cell *1st M_2*.

Abdomen blackish, gray pruinose, including the hypopygium. Male hypopygium generally as in *subunica* but differing in important details. Outer dististyle a small strongly curved rod, the tip subacute. Inner dististyle with the yellow rostral portion long and slender, on outer margin close to base bearing a stout darkened lobe, its surface microscopically roughened. Each gonapophysis appearing as a slender sinuous blackened rod, very gradually narrowed to the acute tip, without a lateral branch, as in *subunica*.

Habitat: Northern Korea. *Holotype,* ♂, Puksu Pyaksan, altitude 4000 feet, June 5, 1939 (Yankovsky). *Allotopotype,* ♀, altitude 4200 feet, June 4, 1939. *Paratopotypes,* 7 ♂ ♀, altitude 3700–4500 feet, June 3–5, 1939 (Yankovsky).

Archilimnophila subunicoides is most closely related to the northern Nearctic *A. subunica* (Alexander), differing especially in the structure of the male hypopygium, as indicated above. The species is less similar to *A. harperi* (Alexander) and *A. unica* (Osten Sacken). I had formerly placed these flies in the genus *Austrolimnophila* Alexander but now believe that the genus *Archilimnophila* is separable though closely allied.

Genus **Limnophila** Macquart

Limnophila (Prionolabis) clavaria n. sp.

Size medium (wing, male, about 9 mm.); thorax brownish black, the surface opaque; legs black; wings broad, yellow, restrictedly patterned with darker; cell M_1 present but small; male hypopygium with the subtending lobe of the outer dististyle large, dark-colored, the style narrowed to an acute apical point, with a single obtuse lateral denticle; inner dististyle simple, with a blunt lobe at near three-fourths the length; gonapophysis appearing as a small straight darkened club, the tip blunt.

Male.—Length, about 8.5 mm.; wing, 8.8 mm.; antenna, about 1.6 mm.

Rostrum and palpi black. Antennae 16-segmented, black throughout; basal flagellar segments oval, the outer ones more elongate-oval; verticils of outer segments long and conspicuous. Head brown, opaque; anterior vertex broad.

Thoracic dorsum almost uniformly brownish black, the surface opaque by a sparse brownish yellow pollen. Pleura black, sparsely pruinose; dorsopleural membrane dark. Halteres yellow, the knobs a trifle more darkened. Legs with the coxae black, sparsely pruinose; remainder of legs black, the femoral bases very restrictedly brightened. Wings broad, ground color yellow, the prearcular and costal fields somewhat clearer yellow; stigma long-oval, brown; vague paler brown seams over anterior cord, vein R_5, the entire length of vein Cu and in the axillary portion of cell *2nd A;* veins dark brown, paler in the brighter yellow portions. Venation: Sc_1 ending just before the level of the fork of *Rs*, Sc_2 at its tip; R_{2+3+4} about three-fifths R_{2+3}; R_{1+2} a little longer than R_2; cell M_1 small, approximately one-half its petiole; *m-cu* at or just beyond midlength of cell *1st M₂*.

Abdomen, including hypopygium, black, the surface subnitidous, with black setae. Male hypopygium with the central region of the posterior border of the ninth tergite slightly produced and with a broad U-shaped notch, the lobes thus formed conspicuous. Outer dististyle with the subtending lobe large, dark-colored; style gradually narrowed to an acute curved apical point, with at most a single evident lateral denticle; outer margin with very long setae. Inner dististyle simple, the outer fourth slender, at point of narrowing with a blunt lobe, the apex of which is microscopically roughened or tuberculate. Aedeagus compressed-flattened, dark-colored. Gonapophysis appearing as a small straight darkened rod that widens very gradually outwardly, the apex obtusely rounded or weakly notched (in one apophysis of the unique type), the whole structure appearing as a small dusky club.

Habitat: Northern Korea. *Holotype,* ♂, Kankyo Nando, Puksu Pyaksan, Toorisani, altitude 6000 feet, June 22, 1939 (Yankovsky).

Limnophila (Prionolabis) clavaria is quite distinct from all other regional members of the subgenus, differing especially in the structure of the male hypopygium, as the dark-colored clavate gonapophyses. The fly is entirely different from the other species known from the Asiatic mainland.

Limnophila dis n. sp.

Allied to *yankovskiana;* general coloration black, including body and antennae; antennae of male elongate, exceeding one-half the length of wing; femora black, tibiae and tarsi dark brown; wings broad, with a strong blackish tinge; cell R_3 sessile or very short-petiolate; cell M_1 lacking; *m-cu* at or beyond midlength of cell *1st M₂*; male hypopygium with the outer dististyle a slender straight rod that is very shallowly and unequally bifid at tip, the longer spine being axial, the lateral branch much smaller.

Male.—Length, about 6–6.5 mm.; wing, 7–8 mm.; antenna, about 4.2–4.5 mm.

Rostrum and palpi black. Antennae of male elongate, as shown by the measurements; scape and pedicel black, flagellum dark brown;

flagellar segments apparently only 13 in number, elongate-cylindrical, with long coarse verticils and a shorter but conspicuous erect pubescence. Head dull black.

Thorax black, the surface subnitidous by a sparse pruinosity, pleura more heavily pruinose. Halteres infuscated, the extreme base of stem paler. Legs with the coxae black, very sparsely pruinose; trochanters dark; femora black, tibiae and tarsi dark brown or brownish black, the tips of the segments narrowly more darkened. Wings broad, with a strong blackish tinge; stigma oval, scarcely darker than the ground; scarcely indicated darker seams along the cord; veins brown. Venation: Sc_1 ending opposite fork of Rs, Sc_2 a short distance from its tip; Rs elongate, square and more or less spurred at origin; cell R_3 usually sessile, in cases barely so, with vein R_{4+5} punctiform or very short, in other cases, including the type, with R_{4+5} nearly as long as the basal section of R_5; in still other specimens, cell R_3 short-petiolate, with a short element R_{2+3+4} present; vein R_2 faintly indicated, about one-half R_{1+2}; cell M_1 lacking; m-cu opposite or shortly beyond midlength of cell *1st* M_2; vein *2nd* A moderately sinuous.

Abdomen, including hypopygium, black. Male hypopygium with the tergal region feebly emarginate. Outer dististyle a slender straight rod, very shallowly and unequally toothed at apex, the longer tooth axial, the shorter spine scarcely more than a tubercle, placed on mesal edge some distance from tip; inner dististyle unusually short and squat, the tip slightly decurved, obtuse.

Habitat: Northern Korea. *Holotype*, ♂, Puksu Pyaksan, altitude 5500 feet, June 13, 1939 (Yankovsky). *Paratopotypes*, 10 ♂♂, June 13-23, 1939 (Yankovsky).

Generally similar to *Limnophila yankovskiana* Alexander, likewise from the mountains of northern Korea, agreeing in the black coloration, elongate antennae of male, sessile or subsessile cell R_3, loss of cell M_1 and other characters, differing in the shorter antennae of male, more blackened wings, with the venational details, particularly of the medial field, distinct, and especially in the structure of the male hypopygium, notably the outer dististyle.

Limnophila pietatis n. sp.

General coloration of thorax reddish yellow, without pattern; antennae (male) elongate, the flagellar segments beyond the first uniformly black; femora yellow, the tips abruptly and very conspicuously blackened; wings with a weak brownish yellow tinge, restrictedly patterned with brown; Sc moderately long, Sc_1 ending before level of fork of Rs; R_{2+3+4} subequal to $R_{2\ 3}$; abdomen yellow, the anterior lateral angles of both tergites and sternites conspicuously blackened, in male, the outer three segments blackened; male hypopygium with the outer dististyle relatively short, glabrous, the apical outer angle produced into a slender fingerlike point; gonapophysis with seven or eight scattered spines on outer portion.

Male.—Length, about 7 mm.; wing, 6.8 mm.; antenna, about 3.2 mm.

Female.—Length, about 8.5 mm.; wing, 7.5 mm.

Rostrum orange yellow; palpi black. Antennae (male) elongate,

as shown by the measurements; basal three segments yellow, succeeding segments passing through dark brown to black; flagellar segments elongate-subcylindrical, the longest verticils a little shorter than the segments; in addition to the verticils, segments clothed with a dense erect pale pubescence. Head yellow, sparsely pruinose; anterior vertex broad, approximately four times the diameter of scape. In the female referred to this species, the antennae are shorter, the scape blackened; head above much clearer gray.

Entire thorax uniformly reddish yellow, subnitidous, without pattern. Halteres relatively long, stem yellow, knob very slightly darker. Legs with the coxae and trochanters yellow; femora yellow, the tips rather broadly and abruptly black, occupying about the outer seventh or eighth of segment; tibiae paler yellow, the base diffusely infuscated, the tip more narrowly and abruptly blackened; basitarsi and second tarsal segment almost white, the tips darkened; outer tarsal segments brownish black. Wings with a weak brownish yellow tinge, the prearcular and costal fields clear light yellow; a restricted brown pattern, including stigma, a large cloud at origin of Rs, cord, outer end of cell *1st* M_2, and less evidently elsewhere; outer radial cells even less distinctly infuscated; veins brown, yellow in the brightened areas. Venation: Sc moderately long, Sc_1 ending before fork of Rs, Sc_2 even longer, opposite this fork; Rs elongate, square and in cases, including the type, long-spurred at origin; R_{2+3+4} relatively long, about equal to R_{2+3}, in direct longitudinal alignment with Rs; R_{1+2} and R_2 subequal; inner ends of cells R_4, R_5 and *1st* M_2 in transverse alignment; cell M_1 from one-third to one-half longer than its petiole; cell *1st* M_2 rectangular, with *m-cu* at from one-third to two-fifths its length; vein *2nd* A long, generally paralleling the axillary margin of wing.

Abdomen yellow, the anterior lateral angles of both tergites and sternites two to four, with a conspicuous black area that narrows behind, extending to beyond midlength of segment, on the succeeding segments becoming smaller and less evident, more distinct in female; male with terminal three segments black, only the hypopygium partly brightened; in female, the pale color continued virtually to the end, including the genital shield. Male hypopygium with the outer dististyle relatively short, appearing as a gently curved flattened blade, at end with apical outer angle produced into a slender fingerlike point; surface glabrous except for a single strong seta at basal third. Inner dististyle a little shorter, the basal half or more oval, the outer portion more narrowed; surface of style with conspicuous erect setae. Gonapophysis provided with seven or eight conspicuous acute points distributed over the entire head or apical portion.

Habitat: Northern Korea. *Holotype,* ♂, Puksu Pyaksan, altitude 5000 feet, August 21, 1939 (Yankovsky). *Allotopotype,* ♀, pinned with type. *Paratopotypes,* 3 ♂♂, August 9–21, 1939 (Yankovsky).

Very similar in its general appearance to the western Palaearctic *Limnophila glabricula* (Meigen), of which it may prove to represent a race. The dististyles of the male hypopygium are conspicuously shorter than in *glabricula*. Edwards referred *glabricula* to the subgenus *Phylidorea* Bigot but its position here must still be held as questionable.

Genus **Lipsothrix** Loew

Lipsothrix yamamotoana n. sp.

General coloration dull black; antennae black, relatively long, if bent backwards extending approximately to the wing-root, the flagellar verticils shorter than the segments; femora yellow, the tips brownish black, slightly more extensive on the fore legs where about the outer fifth is included; wings yellowed, the prearcular and costal fields clearer yellow; Sc short, Sc_1 ending about opposite the fork of Rs; Rs relatively long, exceeding four times R_{2+3+4}, the latter shorter than R_{2+3}; inner end of cell R_4 lying only a little proximad of the other elements of the anterior cord; m-cu close to the fork of M.

Male.—Length, about 7–7.5 mm.; wing, 8–8.5 mm.; antenna, about 2.1–2.3 mm.

Rostrum and palpi black. Antennae black, relatively long, if bent backward extending approximately to the wing-root; flagellar segments oval, the constrictions between the segments well indicated; verticils shorter than the segments. Head dull black.

Thorax uniformly dull black. Halteres pale yellow. Legs with the coxae and trochanters yellow; femora yellow, the tips brownish black, slightly more extensively so on the fore legs where about the outer fourth or fifth is included; tibiae obscure brownish yellow, the tips narrowly darkened; tarsi brown; claws (male) toothed. Wings with the ground color yellow, the prearcular and costal fields clear light yellow; stigma oval, brown, relatively inconspicuous; veins brown, yellow in the brightened areas, especially at wing base. Venation: Sc short, Sc_1 ending about opposite fork of Rs, Sc_2 at its tip; Rs relatively long, exceeding four times R_{2+3+4}, the latter shorter than R_{2+3}; R_{1+2} very short; inner end of cell R_4 lying only a short distance proximad of the other elements of the anterior cord; cell $1st$ M_2 rather short-rectangular; m-cu close to or just beyond the fork of M.

Abdomen, including hypopygium, black, sparsely pruinose.

Habitat: Japan (Honshu). *Holotype,* ♂, Funakosi, Iwateken, altitude 200 meters, May 23, 1947 (H. Yamamoto). *Paratopotype,* ♂, pinned with the type.

I am very pleased to name this distinct fly for the collector, Mr. Hiromu Yamamoto, to whom I am greatly indebted for many interesting Tipulidae from northern Honshu. From other regional members of the genus, including *Lipsothrix tokunagai* Alexander and *L. yakushimae* Alexander, it is readily told by the coloration and by the structure of the antennae and the venation.

Genus **Gnophomyia** Osten Sacken

Gnophomyia (Gnophomyia) acheron n. sp.

General coloration black; antennae black, the flagellar segments in male relatively long, subcylindrical; wings with a weak blackish tinge, the prearcular field light yellow, stigma not indicated; Sc_1 unusually long; ovipositor with cerci unusually long and slender, gently upcurved; basistyle of male hypopygium with a group of six or seven stout black

setae on mesal face; outer dististyle a long, nearly straight blackened rod, the tip obtuse.

Male.—Length, about 7.5–8 mm.; wing, 7.5–8 mm.; antenna, about 2–2.1 mm.

Female.—Length, about 8 mm.; wing, 8 mm.

Rostrum and palpi black. Antennae black, the scape a little more pruinose; flagellar segments in male relatively long, subcylindrical, longer than the verticils. Head dull black, the anterior vertex broad, heavily dusted with gray.

Thorax black, subopaque, the ventral pleurites more distinctly pruinose. Halteres pale yellow. Legs with the coxae and trochanters black; remainder of legs black, the femoral bases very narrowly yellowed, most evident on the fore legs. Wings with a weak blackish tinge, the prearcular field light yellow; stigma not indicated; veins dark brown. Venation: Sc_1 ending approximately opposite R_2, Sc_2 nearly opposite the fork of Rs, so Sc_1 is unusually long, subequal to or even exceeding the combined veins R_{2+3+4} and R_{2+3}; veins R_3 and R_4 extending generally parallel to one another, slightly divergent; cell *1st M_2* shorter than vein M_4, with *m-cu* at near one-third its length.

Abdomen, including hypopygium, black. Ovipositor with the cerci unusually long and slender, gently upcurved. Male hypopygium with the region of the ninth tergite with a shallow emargination, the lobes very broad, at base of notch with a few short strong spines. Mesal face of basistyle with a group of six or seven stout black setae on mesal face. Outer dististyle a long, nearly straight blackened rod, its tip obtuse. Inner dististyle much smaller, broad at base, the outer half strongly narrowed and upturned, on dorsal face of the enlarged part with a compact group of about eight long black spinous setae. Phallosome massive, subquadrate in outline, the caudal margin very gently emarginate medially.

Habitat: Japan (Honshu). *Holotype,* ♂, Funakosi, Iwateken, altitude 200 meters, May 23, 1947 (H. Yamamoto). *Allotopotype,* ♀. *Paratopotypes,* 6 ♂ ♀.

The only approximately similar regional species is *Gnophomyia* (*Gnophomyia*) *nycteris* Alexander, still known to me only from the female. This differs in the details of coloration and venation and especially in the structure of the ovipositor.

Genus **Ormosia** Rondani

Ormosia (Ormosia) weymarni n. sp.

Mesonotum brownish gray, the postnotum and pleura yellow; antennae short; halteres with knobs dusky; legs yellowish brown, the tips of the femora and tibiae narrowly darkened; wings grayish yellow, the prearcular and costal fields clearer yellow; macrotrichia of cells long and conspicuous but relatively sparse, more or less restricted to the central portions of the cells; phallosome unblackened.

Male.—Length, about 4–4.2 mm.; wing, 4.4–4.8 mm.

Rostrum and palpi pale. Antennae short, if bent backward extending about to mid-distance to wing root or slightly beyond; scape and

pedicel light brown, flagellum black; flagellar segments oval, the verticils a little exceeding the segments. Head dark gray.

Pronotum obscure yellow. Mesonotal praescutum brownish gray, without clearly defined stripes; scutum and scutellum brownish gray, the postnotum yellow. Pleura obscure yellow. Halteres dusky, the basal half of stem yellow. Legs with the coxae and trochanters yellow; femora yellowish brown, the bases clearer yellow, the apices passing into brown; tibiae obscure yellow, the tips narrowly infuscated; tarsi brownish black. Wings grayish yellow, the prearcular and costal fields clearer yellow; veins pale brown, more yellowed in the brightened costal portions. Macrotrichia of cells relatively long but sparse, lacking in the basal portions of cells R, M and Cu; in the other cells more or less restricted to the central parts of the cells remote from the veins. Venation: Sc_1 ending about opposite fork of Rs, Sc_2 about opposite one-fifth to one-sixth the length of Rs; cell M_2 open by the atrophy of the basal section of M_3; m-cu just before the fork of M; Anal veins divergent.

Abdominal tergites darkened medially, paler on sides; sternites and hypopygium yellow. Male hypopygium with the outer dististyle relatively small, provided with rows of scabrous blackened points; inner dististyle subequal in length, pale. Phallosome appearing as tumid, entirely unblackened plates that are contiguous on the midline.

Habitat: Manchuria, northern Korea. *Holotype,* ♂, Kaolingtze, Manchuria, May 30, 1941 (received from Michael Weymarn). *Paratype,* ♂, Ompo, northern Korea, altitude 600 feet, May 2, 1938 (Yankovsky).

This interesting fly is named for Mr. Michael Weymarn, to whom I am indebted for many Tipulidae from Manchuria. Despite the different venation, the fly seems closest to *Ormosia (Ormosia) confluenta* Alexander, of Japan, and *O. (O.) yankovskyi* Alexander, of northern Korea, both of which have cell M_2 of the wings open by the atrophy of m and differ further in the color of the body and legs and in the details of structure of the male hypopygium. Other allied species in the northwestern Nearctic fauna include *O. (O.) absaroka* Alexander, *O. (O.) flaveola* (Coquillett), and others.

Genus **Molophilus** Curtis

Molophilus (Molophilus) hoplostylus n. sp.

Belongs to the *gracilis* group; general coloration blackened; antennae of male elongate, approximately two-thirds the body, black throughout; flagellar segments fusiform, with whorls of long erect setae at midlength; wings broad, suffused with blackish; costal fringe long and dense; vein *2nd A* short; male hypopygium with three dististyles, the longest a gently curved black rod with numerous denticles along the face; third dististyle a small fingerlike fleshy lobe that bears numerous very long setae.

Male.—Length, about 5 mm.; wing, 4.8 mm.; antenna, about 3.5 mm.

Rostrum and palpi black. Antennae (male) elongate, as shown by

the measurements, black throughout; flagellar segments fusiform, with whorls of very long erect setae at midlength of the individual segments. Head black.

General coloration of thorax black, probably pruinose in fresh specimens, the unique type discolored; pretergites restrictedly yellow. Halteres black. Legs with the coxae and trochanters brown; remainder of legs dark brown. Wings broad, with a weak blackish tinge; veins and macrotrichia brownish black; costal fringe (male) long and dense. Venation: R_2 in approximate transverse alignment with *r-m; m-cu* less than one-third the length of the petiole of cell M_3; vein *2nd A* unusually short, ending some distance before the level of *m-cu*.

Abdomen, including hypopygium, black. Male hypopygium complex; apex of basistyle with a cylindrical dorsal lobe that is provided with long retrorse setae, and a longer ventral lobe that is dilated on the basal two-thirds or more, provided with long erect setae, the apical part slender and glabrous, the tip obtuse. Three dististyles, the longest a gently curved black rod that narrows very gradually into a long straight spine, the margin, especially the lower or concave one, with microscopic denticles, one at near midlength longer; second dististyle nearly as long, straight, the outer third a more slender blackened spine; third dististyle a small fingerlike fleshy lobe that bears numerous very long setae, these longer than the style itself. Phallosomic plate obtuse at tip, the surface with exceedingly microscopic setulae. Aedeagus elongate, subtended by a flange, the apex more or less bilobed.

Habitat: Formosa. *Holotype,* ♂, Musha (Wuse), Telchung District, altitude 1000 meters, August 23, 1947 (J. L. Gressitt); type in the Lingnan University Collection.

The present fly belongs to a subgroup having rather numerous species in the Philippines and elsewhere in southeastern Asia, but to this date with no known representatives in Formosa or northward. The most similar Philippine species include *Molophilus (Molophilus) banahaoensis* Alexander, *M. (M.) hispidulus* Alexander, and *M. (M.) injustus* Alexander, all differing from the present fly, and among themselves, in the structure of the male hypopygia.

FORMIC ACID PRODUCTION AMONG THE FORMICIDAE

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INTRODUCTION

Although it has been known for a long time that ants secrete formic acid there are very few papers on the subject which are accompanied by analytical data. Poulton (1901), in a brief note, described an apparatus which could be used to collect the venom of ants. He stated that the percentage of anhydrous acid in the venom of *Formica rufa* fluctuated widely and that strong samples contained 60% to 70% of acid. Melander and Brues (1906) estimated formic acid by the reduction of mercuric chloride, but they found that simple titration with N/2 potassium hydroxide after steam distillation from weak ethyl alcohol gave more consistent results. Sexual forms never gave an acid reaction with the exception of *Formica* females. These authors made the extremely important observation that only the genera not having stings secrete acid. *Crematogaster* (Myrmicinae) they say "may prove to be an exception, but in this case most likely some other acid is present." *Forelius* (Dolichoderinae) contained no acid but *Pachycondyla* (Pomerinae), although provided with a powerful sting, contained acid up to 1.5% of its body weight. *Formica fusca* var. *gnava* workers contained acid to the extent of from 0.5% to 12.68% of their body weight. Stumper (1922a), using Duclaux's method for estimating formic acid, found that it was the only free volatile acid present in the venom of *Formica rufa* and *Cataglyphis bicolor*. Later (1922b) the same author showed that the venom of *Formica rufa* contained from 21% to 72% (*i.e.*, 5–17M) of formic acid. He also showed that temperature affected the rate of secretion and his results gave a Q^{10} of 2.16. He pointed out that the tissues of the poison sac and the ejaculatory duct resist the action of such a strong acid and that the mechanism of that resistance is quite unknown. Donisthorpe (1927) gave results obtained by Briscoe using *Formica rufa* workers which produced from 1.8 to 2.1 mg. of acid per ant. It will be seen, therefore, that the production of formic acid is limited to one subfamily of the Formicidae, with only two exceptions—*Pachycondyla* and *Crematogaster*. Both these are inconclusive since it was only shown that an acid was present and there is no evidence as to it being formic acid. Thus, so far as is known, the Formicidae alone among the ants secrete formic acid. This sub-

family is characterized by the rudimentary nature of the sting and the marked development of a venom sac in which the formic acid is stored.

Stumper (1923) was the first to point out the association between the presence of the poison apparatus and well-developed glands with the rudimentary nature of the sting and the secretion of formic acid. He showed that while the Formicinae always secrete formic acid, the Dolichoderinae and the Myrmicinae never do so.

Many authors quote figures unsubstantiated by either references or experiments; for example, Ceballos (1943, p. 331) states "The poison of these ants (Formicinae) show concentrations of formic acid as high as 72% although that of the species of other subfamilies contain no formic acid." (Translation). I have been unable to find any other papers based on analytical work. It will therefore be seen that, as yet, there is little known about formic acid secretion and that there is a wide field for research.

PRESENT WORK

(a) *Titration method*

In the experiments described here an attempt was made to estimate the amount of acid present in each species available. The procedure was as follows:

Single ants were weighed on a micro balance and used for each estimation which was done on a micro-chemical scale. The acid was estimated by titration with $\dfrac{N}{200}$ NaOH with phenolphthalein (one drop) as indicator. $\dfrac{N}{800}$ NaOH was used in early experiments but it was found that this solution lost its strength rather rapidly because of absorption of CO_2 from the atmosphere. A single ant was taken alive, weighed and dropped into one ml. of distilled water which was then brought to the boil. A further ml. of water was then added to wash the sides of the test-tube and wash back the slight condensation vapour. One drop of phenophthalein was then added and the solution titrated from a Bang burette with the alkali until it became colourless. It was found that a blank titration was necessary and subtraction of the blank made a considerable difference to the result. In the tables which follow, I give in brackets after the percentage of body weight these uncorrected figures. By chance a simple method for detecting minute amounts of acid was discovered when an ant fell into a drop of B.D.H. soil indicator and turned the indicator from green to bright red. It was found by experiment that using one drop of indicator as little as 1.1γ of HCOOH (1γ being one millionth of a gram) could be detected. This method was used to test all available species. Tables I, II, and III, show the results obtained.

These are the only acid-containing species found in this country and which, as a result, I have been able to use for estimation.

Leptothorax acervorum, and all the Irish species of *Myrmica* except *schenki* have been tested with negative results. These figures are interesting in that they are the first set giving complete data and using

TABLE I

FORMIC ACID CONTENT OF FORMICA FUSCA WORKERS

Specimen No.	Weight of Specimen in Micrograms	Weight of Acid in Micrograms	Percentage of Total Body Weight
1	2,900	106	3.96 (4.96)
2	4,200	0	0 (0.64)
Workers tested 3	3,500	0	0 (0.80)
within 24 hours 4	4,100	76	1.85 (2.75)
of collection..... 5	3,100	0	0 (0.68)
6	10,000	57	0.57 (0.94)
7	12,100	27	0.22 (0.53)
8	9,200	30	0.32 (0.73)
9	10,000	57	0.57 (0.94)
10	12,200	71	0.58 (0.89)
Eight workers collected 3 days previously.............	40,200 (total)	5,219	1.29
Ten workers dead one month..........	35,000 (total)	2,182	6.31
Average...............			0.81

TABLE II

FORMIC ACID CONTENT OF LASIUS FLAVUS WORKERS

Specimen No.	Weight of Specimen in Micrograms	Weight of Acid in Micrograms	Percentage of Body Weight
Alive............... 1	900	60	6.66 (10.8)
2	800	0	0 (4.7)
3	2,200	4.1	1.86 (3.5)
4	1,100	69	6.27 (9.2)
Dead 24 hours...... 5	1,700	16	0.94 (3.1)
6	1,100	2	0.18 (3.5)
Average...............			2.65

TABLE III

FORMIC ACID CONTENT OF LASIUS NIGER WORKERS

Specimen No.	Weight of Specimen in Micrograms	Weight of Acid in Micrograms	Percentage of Body Weight
1	2,100	88	4.19 (5.9)
Dead less than 12 2	2,100	3	0.14 (2.8)
hours............. 3	2,600	389	14.96 (16.4)
4	2,000	239	11.95 (13.8)
5	1,500	106	7.07 (9.5)
6	2,400	191	7.96 (9.5)
Average...............			7.71

single specimens.   The following observations may be made on these figures:

(1) While the figures compare very favourably with other available figures, it will be noticed that they tend to the lower than those hitherto published.   It is possible that this is due to the fact that in the present experiments care was taken to do control experiments.   In all cases the results have been used in the subsequent calculations of the percentage of formic acid in the body.

(2) It will be noted that there is a wide scatter in the results.   This might be due to the fact that one might be dealing in one case with a specimen whose poison gland was full, and in another with one whose gland has just been emptied.

(3) One may note the high values obtained with specimens of *L. niger*, which were dead.   In general dead specimens gave higher values than did living ones; a fact which may account for the higher percentages obtained by previous experimenters, who do not state whether the ants were alive or not when they began the determinations.

It will be seen that the method used depended merely on the acidic properties of formic acid.   It is possible that there are other titratable acids in ants as well as formic acid.   It was, therefore, decided to try to devise a quantitative method that would be specific for formic acid.   The following methods were tried.

(b) *Microdiffusion Method*

This method, based on the liberation of bromine, made use of the Conway Unit in the outer chamber of which 1 ml. of the formic acid was placed.   The central chamber contained 1 ml. of a standard sodium hypobromite solution.[3]   One ml. of normal sulphuric acid was added to the outer chamber and the units sealed with a beeswax-paraffin fixative and incubated at 50° C. for 24 hours.   The units were then allowed to cool and the sodium hypobromite sucked out into a tube and diluted with 1 ml. distilled water and acidified with 10% hydrochloric acid until the bromine just appeared.   The tube was then stoppered and left in the dark for 30 minutes when it was saturated with potassium iodide.   It was then titrated with $\frac{N}{20}$ thiosulphate from a Conway burette.   The difference between this titration and that for the blank unit gave the amount of formic acid.   1 ml. $\frac{N}{20}$ thiosulphate being equivalent to 1.15 mg. formic acid.[4]

---

[3]This was made up as follows: 15 grams of pure sodium hydroxide was dissolved in 450 ml. of distilled water in a 500 ml. volumetric flask.   When cold 5 ml. of bromine was added and dissolved by shaking.   The whole was then made up to 500 ml. and kept in a dark stoppered bottle in the dark.   The solution was standardized by diluting 5 ml. of it with 50-70 ml. of water and adding 20 ml. of 10% hydrochloric acid and 1 gram of potassium iodide.   After two minutes the iodine liberated was titrated with $\frac{N}{20}$ thiosulphate.

[4]Reference to (1) microdiffusion method in Conway 1947, and (2) to the chemical basis of the method in Rupp 1905, and Thorpe and Whiteley 1925.

It was not expected that all the formic acid would diffuse across into the central chamber but (in a series of experiments) the yield proved to be very poor, only 29% of the formic acid coming across. The sodium hypobromite in the central chamber was replaced by potassium hydroxide, the former then being added after cooling. The results, however, continued to be both erratic and low although the blanks became fairly constant indicating that the method rather than the technique was at fault. It is probable that higher incubation temperatures (about 80° C.) should have been used, but at these temperatures the fixative is difficult to control.

(c) *Colorimetric Method*

The principle was to reduce the formic acid to formaldehyde with magnesium in the acid medium. The formaldehyde was then allowed to react with 0.5 ml. of 1% phenylhydrazine in 2% hydrochloric acid and 0.05 ml. of 5% potassium ferricyanide until the colour was fully developed when it was estimated with Pulfrich photometer using filter 9 and 20 mm. stratum length. This reaction gave a good colour which however showed marked fading. An endeavour to overcome this using different reaction times eventually gave a good extinction curve, using standard formic acid solutions. When, however, ant extracts were used the fading was uncontrollable and after many attempts the method had to be abandoned. (The method will detect as little as 50γ of formic acid and is useful qualitatively.)

The present method gave a colour reaction with *Formica fusca*, *Lasius niger* and *L. flavus* but none with any species of *Myrmica* thus confirming the presence of formic acid in formicine species, and its absence from myrmicine ones.

SYNTHESES OF FORMIC ACID IN ANTS

Nothing is known of the method of synthesis of the acid in the ants. The best that can be done is to suggest the possible modes which might be used by the organism for this synthesis.

I. $CO_2 + H_2O \rightleftarrows HCHO + O_2$. This is the path suggested for the carbohydrate synthesis in plants, the formaldehyde then being polymerized to monosaccharides by aldol condensations. If we then assume oxidation of the formaldehyde formic acid would result:

$$2 HCHO + O_2 \rightleftarrows 2HCOOH.$$
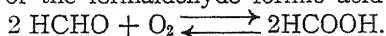
It has recently been shown (cf. Rabinowitch (1945), chapter 4) that the formation of formaldehyde does not account for carbohydrate synthesis in plants so that the probability of this mode of formation is reduced. A point in its favour is that the increased CO_2 production during activity, which is known to occur in insects (Wigglesworth, 1942: 341), would find an outlet in acid production since the greatest amount would be required under such circumstances. The possibility of this mode of synthesis could be tested by bubbling CO_2 and O_2 through an extract of ants and testing for formaldehyde with dimedone. This could not be carried out as no supplies of dimedone were available.

II. Bersin (1938) quotes the results obtained by Stephenson and Stickland with *Bacillus lactis aerogenes* and *B. coli*, in which formic

acid is built up from hydrogen and carbon dioxide by means of the enzyme formic acid dehydrase

$$CO_2 + H_2 \rightleftharpoons HCOOH$$
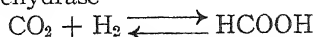
the H_2 coming from a hydrogen donator. This is certainly a possible line of synthesis although the enzyme hydrogen lyase has not been found in any group except bacteria. Now that it is known that symbiotic bacteria produce the vitamins required by insects, and that, furthermore, such symbionts are known in ants of the genera *Formica* and *Camponotus* (cf. Wigglesworth, 1942: 287 ff.), it is by no means impossible that such organisms could form the acid. It is difficult to imagine that the bacteria could produce enough acid at the time required by the insect. Thus a metabolic origin is *a priori* the most likely since acid production would be correlated with the needs of the insect.

III. Formic acid might result as a byproduct of carbohydrate metabolism. Although there are many points at which formic acid might be split off there is nothing to support any of these possibilities. A possible point in the cycle at which the formic acid could come off is at the oxaloacetic acid stage. Instead of it being converted into the enol form and combined with the keto form of pyruvic acid to form oxalocitraconic acid in the oxidative breakdown of glycogen known to occur in insects (cf. Wigglesworth, 1942: 329) the oxaloacetic acid might split off formic acid on hydrolysis, thus:

$$
\begin{array}{l}
COOH \\
| \\
CO \\
| \quad + HOH \rightleftharpoons \\
CH_2 \\
| \\
COOH
\end{array}
\qquad
\begin{array}{l}
COOH \\
| \\
CO \quad + HCOOH \\
| \\
CH_2OH
\end{array}
$$
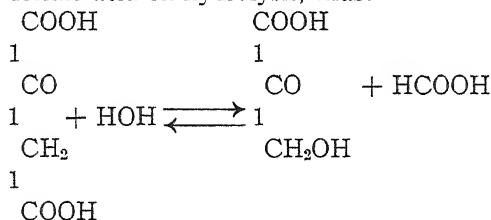
The former compound by picking up a hydrogen molecule would give rise to the familiar pyruvic acid in the keto form; as follows:

$$
\begin{array}{l}
COOH \\
| \quad + H_2 \rightleftharpoons \\
CO \\
| \\
CH_2OH
\end{array}
\qquad
\begin{array}{l}
COOH \\
| \\
CO \; H_2O \\
| \\
CH_3
\end{array}
$$
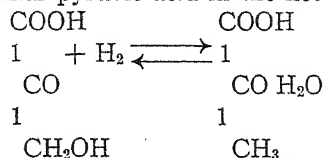
Another possible method is by the hydrolysis of ketoglutaric acid instead of the usual simple oxidation, thus:

$$
\begin{array}{l}
COOH \\
| \\
CH_2 + H_2O \rightleftharpoons \\
| \\
CH_2 \\
| \\
CO \\
| \\
COOH
\end{array}
\qquad
\begin{array}{l}
COOH \\
| \\
CH_2 + HCOOH \\
| \\
CH_2 \\
| \\
COOH
\end{array}
\qquad \text{succinic acid}
$$
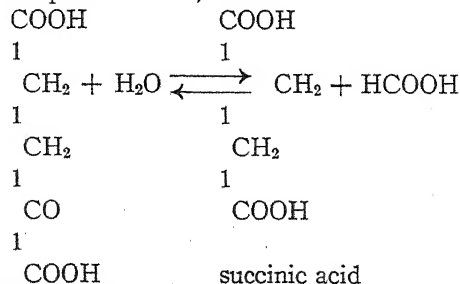
This is quite a likely method.

IV. Finally, the possibility of a derivation from amino acids cannot be ignored. Glycine $CH_2.NH_2COOH$, which occurs to the extent of 3.5% in the silkworm moth (Wigglesworth, 1942: 327) could form formic acid by deamination with the consequent oxidation of formaldehyde thus:

$$H_2 - C.COOH \qquad H_2 - C.COOH$$
$$1 \qquad\qquad\qquad 11$$
$$NH_2 \xrightleftharpoons{\hspace{2cm}} O \quad +H_2O \xrightleftharpoons{\hspace{1cm}} HCOOH+H_3CO_2$$
$$\text{glycine deaminase}$$
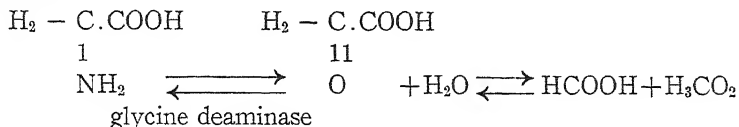
If glycine deaminase is found in ants it would furnish strong support for this possibility.

It was considered worth while outlining these possibilities, although at present I have no evidence to support any of these hypotheses which, nevertheless, have been stated. It is hoped that in the future I may have the time and facilities, not now at my disposal, to test out the theories which are worthy of further investigation.

It will be seen that there is still a great deal to be done in the present field. The main difficulty is to find a reliable method of estimating micro-quantities of formic acid in ants.

SUMMARY

1. Previous work is reviewed and the problems yet to be worked out are indicated.

2. The results of formic acid estimations using a titration method are given, and they are shown to be lower than those previously recorded. It is suggested that this may be because no blank estimations were made by previous workers, and also that they used dead specimens.

3. An unsuccessful attempt to produce a reliable method of formic acid estimation on a micro-diffusion basis is described. A qualitative colorimetric method is described which will detect as little as 50γ of formic acid. It did not prove to be useful as a quantitative method.

4. Four possible modes of formic acid synthesis in the ant are suggested and discussed.

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DEGRADATION OF DDT BY RESISTANT AND SUSCEPTIBLE STRAINS OF HOUSE FLIES[1]

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It has been demonstrated by Sternburg et al, (1950) and Perry and Hoskins (1950) that certain strains of DDT-resistant house flies have an abnormal facility to degrade DDT to its non-toxic metabolite DDE (1, 1-dichloro-2, 2-bis (p-chlorophenyl) ethylene). The difference between susceptible and resistant strains is so great in this respect that it would seem to be a major factor in the explanation of the nature of DDT-resistance. It seemed that further studies on the metabolism of DDT by the two strains of flies might lead to a clarification of the significance of DDT-degradation in relation to the acquisition of DDT-resistance and at the same time contribute much needed information on the mode of action of DDT. The previous work indicated the need for information concerning the site or sites at which DDT is degraded in resistant flies. It also seemed desirable to extend the studies on DDT metabolism to stages other than the adult.

The strains of flies, methods of rearing, extraction and analysis of DDT and metabolites, and application of chemicals to insects were for the most part the same for the present report as those described by Sternburg et al, (1950). In any instance where changes have been made they are fully described.

SITE OF DDT DEGRADATION

Preliminary attempts to locate the sites of DDT degradation in resistant flies consisted in the analysis of ether extracts of gross tissue dissections from adult flies which had been previously treated with DDT. The object was to locate areas of the body where the metabolite DDE accumulated in greatest quantity and then to explore those particular areas in greater detail with respect to the nature of the tissues associated with its accumulation and degradation. Twenty DDT-resistant flies were each treated with 10 μg. of DDT applied to the mesonotum in 1 mm.^{3} of ethanol. They were then held for 24 hours in a cheesecloth-covered erlenmeyer flask, after which time they were rinsed with ether to remove DDT from the body surface. The flies were then frozen until they could be dissected. The tissues dissected from the flies were not free from contamination of other materials such as blood and fat bodies. No attempt was made to dissect tissues from the appendages, and the tissues designated as cuticle actually consisted of cuticle, hypoderm, and stubs of muscle at their points of attachment to the cuticle. The designations given in Table I, therefore, indicate the greater proportion of the particular tissue which was assayed for DDT and its metabolites. The total of all tissues analyzed represents the analysis of a whole fly.

The data recorded in Table I show that approximately three-fourths of the total dosage of 200 µg. of DDT applied to the 20 flies remained on the outside of the flies and was readily recovered in the ether rinse as unmetabolized DDT. The remainder of the total dose, approximately 50 µg., could be partially accounted for by the total of 34.5 µg. of DDE recovered from various tissue extracts. The recovery of DDT and its metabolite DDE is unexpectedly good in view of all the manipulations involved, and the fact that the pooled fly tissues in some cases represented such a small amount that they could have contained DDT and metabolites in quantities too small to assay.

TABLE I

RECOVERY OF DDT AND DDE FROM POOLED TISSUES FROM RESISTANT FLIES 24 HOURS AFTER TOPICAL TREATMENT WITH 10 µg. DDT TO THE MESONOTUM OF EACH FLY

TISSUE ANALYZED*	RECOVERY PER FLY	
	µg. DDE	µg. DDT
Cuticle of head	0.10	0.00
Cuticle of thorax	0.32	0.00
Cuticle of abdomen	0.58	0.00
Legs and wings	0.20	0.00
Brain and thoracic ganglion	0.00	0.00
Thoracic muscles	0.28	0.00
Fore gut	0.00	0.00
Mid gut	0.15	0.00
Hind gut	0.10	0.00
Mal. tubules	0.00	0.00
Sex organs	0.00	0.00
Total amount, internal	1.73	0.00
External body surface	0.0	7.53
Total recovered based on molecular wt. of DDT	....	9.45

*Total of all tissue assayed equals analysis of whole insect.

The significant features of the data in Table I are that DDE may be found in most of the areas of the body but is most abundant in cuticle of the flies in the regions of the body where the dosage was applied. This suggests the possibility that DDT may be degraded to DDE by resistant flies during the time it is being absorbed through the cuticle-hypoderm. The fact that some DDE was found in or on the intestinal tract suggested the possibility that the flies might be getting small oral doses of DDT by sponging the contaminated surfaces of other flies or the flask in which they were held.

These observations led to a second experiment in which the mouth parts, legs, and wings of 20 resistant flies were removed before treatment with DDT at a dosage of 10 µg. per fly. The flies were then dissected into the various fractions indicated in Table II and analyzed

for DDT and metabolites at various intervals after application of the compound.   The flies treated in this manner remained alive for as long as 24 hours after treatment.

The recovery of DDT and metabolites from the treated flies ranged from 76 to 90 per cent of the theoretical quantity.   The loss is probably accountable for largely by mechanical means such as contamination of equipment used in handling and dissecting the flies.   Two additional causes for loss may be from the metabolism of DDT to form products which do not respond to the analytical method of Schecter *et al*, (1945), and the probability that some of the tissues contained DDT or

TABLE II

Recovery of DDT and DDE from Pooled Tissues Dissected from Groups of 10 Resistant Flies at Various Times After They Were Treated Topically with 10 μG. DDT per Fly After Removal of Mouthparts, Legs, and Wings

MATERIAL ASSAYED*	μG. OF DDT AND DDE RECOVERED PER FLY					
	4 Hours		8 Hours		24 Hours	
	DDT	DDE	DDT	DDE	DDT	DDE
Internal:						
Entire head........	0.00	0.00	0.00	0.10	0.00	0.33
Thoracic cuticle....	0.00	0.35	0.14	0.22	0.16	0.66
Thoracic muscle....	0.00	0.00	0.00	0.00	0.00	0.00
Abdominal cuticle..	0.00	0.10	0.00	0.20	0.00	0.41
Abdominal gut.....	0.00	0.00	0.00	0.00	0.00	0.00
Total internal....	0.00	0.45	0.14	0.52	0.16	1.40
External body surface.	8.30	0.00	6.90	0.00	7.25	0.00
Total recovered based on molecular wt. of DDT..............	8.80		7.62		8.96	

*Total of all tissue assayed equals analysis of whole fly.

metabolites in amounts too small to determine.   It is significant, however, that detoxification of DDT applied topically to resistant flies may occur in the cuticle-hypoderm of the body area covered by the treatment.   The fact that neither DDT nor DDE was found in any of the internal tissues of the flies in measurable quantities suggests that either DDT produces its affects by interfering with the physiology of the peripheral body areas or only a minute fraction of the topical lethal dose is required to be centrally distributed in the insect.   It is of interest to note that where the mouth-parts are removed before treatment that DDE does not appear in the intestinal tract and other tissues of the body.   It is assumed, therefore, that the presence of DDE found in these areas of the body (Table I) was due to the flies taking up DDT orally from contaminated surfaces.

The possibility that resistant flies are able to degrade DDT by means of the digestive tract led to the next experiment in which 20 resistant

flies were allowed to feed on milk containing 2 mg. of DDT per ml. of milk. The flies were permitted to feed until satisfied and then held for 15 hours without further feeding. They were then dissected and analyzed for the presence of DDT and metabolite in various tissues. The results, shown in Table III, indicate that degradation of DDT can occur in the digestive tract, as well as in the cuticle-hypoderm. DDE formed in the digestive tract apparently is transported to all parts of the body, whereas non-metabolized DDT is retained in the digestive tract and does not accumulate in other parts of the body. The ability of resistant flies to degrade oral dosages of DDT before any has reached a vital site thus appears to be a further factor in resistance to DDT.

TABLE III

RECOVERY OF DDT AND DDE FROM POOLED TISSUES DISSECTED FROM 20 RESISTANT FLIES 15 HOURS AFTER FEEDING ON MILK CONTAINING 2 MG. DDT PER ML.

TISSUE ANALYZED*	RECOVERED PER FLY	
	μg. DDT	μg. DDE
Cuticle, head...............................	0.00	0.35
Cuticle, thorax............................	0.00	0.85
Cuticle, abdomen..........................	0.00	1.09
Brain and thoracic ganglion...............	0.00	0.08
Thoracic muscle...........................	0.00	0.25
Digestive system..........................	0.66	1.34
Total............................	0.66	3.96

*Total of all tissues assayed equals analysis of whole fly.

ABSORPTION AND TRANSPORT OF DDT

The results of attempts to locate the sites of degradation of DDT in resistant flies pointed to the possibility that DDT may not be as widely and generally transported through the body of insects as one would suspect upon reading the literature on the subject. Läuger et al., (1946) reports the recovery of sufficient DDT from the thoracic ganglia of 50 poisoned flies to kill an additional 5 flies. He also reports the recovery of sufficient DDT from the malpighian tubules and gut of a like number of poisoned flies to kill 30 flies. Work of a similar nature done by Bot (1949) would seem to confirm these studies. The latter demonstrates the presence of DDT in the haemolymph of DDT-poisoned insects by transfusing the blood from such insects into normal insects where typical poisoning symptoms developed. He also reports the presence of DDT in the malpighian tubules of poisoned insects as shown by bioassays of extracts of these structures. All attempts on our part to duplicate the findings of these workers have resulted in failure. In view of the fact that the manipulations involved are exceedingly difficult to master, it should be pointed out that our failure to confirm the results of these workers may have been the result of faulty technique on our part.

It seemed, however, that if DDT is to be found in the internal tissues of poisoned flies to the extent indicated by the studies of Läuger *et al.* and Bot, that a chemical analysis of extracts of these tissues should reveal, in a relative manner, its distribution.   Groups of fifty DDT-susceptible flies from which the mouthparts had been removed were treated individually with a dosage of 0.5 µg. of DDT per fly applied in 0.5 mm.[3] of ethanol to the mesonotum of CO_2 anesthetized flies. This volume of DDT solution will approximately cover the thorax, with little or none flowing on to the adjacent areas of the head and abdomen. The different lots of flies, thus treated, were rinsed with ether after varying intervals following treatment to remove DDT from the body surfaces.   The flies were then frozen until they could be dissected and the various tissues and body regions analyzed for DDT.

TABLE IV

TISSUE ANALYZED*	µG. DDT RECOVERED PER FLY		
	3.5 Hours	9 Hours	24 Hours After Treatment
Entire head.................	0.00	0.00	0.00
Thoracic cuticle, legs and wings.....................	0.08	0.17	0.21
Thoracic muscles, fore gut and ganglion..............	0.00	0.00	0.00
Entire abdomen.............	0.00	0.00	0.00
External body surface........	0.30	0.20	0.14
Total recovered........	0.38	0.37	0.35

*Total of all tissue assayed equals analysis of whole fly.

The results of this study are presented in Table IV.   It is apparent from these data that the amount of DDT applied to the flies is for the most part to be found on the external parts of the body even in flies assayed 24 hours after treatment. This is shown by the high recovery of DDT in the ether rinse of the flies.   The most significant point is the fact that DDT is not recoverable from the internal tissues of the flies either as DDT or as a metabolite which will respond to the Schechter test.   On the other hand, a substantial quantity of DDT is found in the cuticle-hypoderm of the area where the treatment was applied.   In all cases it was impossible to account for all of the total dosage of DDT applied.   This loss is not due to errors in extraction or other causes because control experiments performed on similar tissue homogenates treated with known dosages of DDT invariably yield 95 to 99 per cent of theoretical quantities on extraction.

These results make it seem impossible that amounts of DDT reported by Läuger (1946) and Bot (1950) could be present in various

internal tissues as indicated by their bioassay studies of tissue extracts from poisoned flies.   Our results support the findings of Roeder and Weiant (1946), Bodenstein (1946), and others, who as a result of physiological experiments believe the effects of DDT may be peripheral in nature.   In view of the fact that substantial quantities of the applied dosages were not recoverable as DDT or a known metabolite, the possibility of DDT being converted to a toxic metabolite is not excluded as a possible explanation of the results of Läuger *et al.*, and Bot. Another possibility is that DDT may be interfering with the normal metabolism of cells in the periphery of the insect to cause them to secrete a toxin which is bioassayable in more centrally located tissues and the haemolymph.

TABLE V

RECOVERY OF DDE APPLIED TOPICALLY TO SUSCEPTIBLE AND DDT-RESISTANT
HOUSE FLIES; 10 FLIES IN EACH GROUP

TIME IN HOURS	STRAIN OF FLY	µG. DDE APPLIED	µG. DDE RECOVERED PER FLY		
			External	Internal	Total
1.5	Susceptible	10	6.07	2.03	8.10
5.5	"	10	5.45	3.75	9.20
10.0	"	10	4.03	5.66	9.69
1.5	Resistant	10	8.95	0.92	9.87
5.5	"	10	7.50	1.72	9.22
18.0	"	10	4.50	4.95	9.45

ABSORPTION AND METABOLISM OF DDE

It was previously pointed out that susceptible flies treated with DDT and assayed at varying intervals following treatment show a gradual loss of DDT which cannot be accounted for by any known metabolite of DDT.   It was thought that this loss might be accounted for if it should be found that susceptible flies readily degrade DDE to an unknown product.   A comparison was therefore made between DDT-resistant and susceptible flies in respect to the absorption and fate of DDE applied topically.

The results of this study are shown in Table V.   In the case of both strains, DDE was recovered in near theoretical quantities in all instances.   Both strains absorb DDE at about the same rate and neither strain is affected in any obvious way at the dosage at which it was applied.   It is apparent that the loss of DDT encountered after application to susceptible flies cannot be explained by the assumption that DDE may be a transitory intermediate in the formation of an unknown metabolite.

ABSORPTION AND METABOLISM OF DDA

In order to check the possibility that DDA (bis- (p-chlorophenyl) acetic acid) might be a transitory metabolite in the metabolism of DDT by susceptible flies, groups of 10 flies were treated topically with 10

μg. DDA per fly in 1 mm.³ of ethanol. The flies were rinsed with ether after 18 hours to remove DDA that had not yet been absorbed. It seemed likely that DDA, once absorbed, would be converted to its salt. Therefore, the tissues of one group of flies were acidified with 3 cc. 6N $H_2 SO_4$ to convert all the DDA present to the acid form. The tissues were then extracted as usual with ether. Another group of flies was extracted without first making the tissues acid. The extract of this group thus only contained DDA present in the flies as such.

The results of this experiment are given in Table VI, along with data from a similar test with DDT-resistant flies. Since 95 to 100 per cent of the DDA could be recovered up to 30 hours after treatment when the tissues were acidified before extraction, it is apparent that neither strain can degrade DDA. Low recoveries when the tissues were

TABLE VI

RECOVERY OF DDA APPLIED TOPICALLY TO SUSCEPTIBLE AND RESISTANT HOUSE FLIES; 10 SUSCEPTIBLE FLIES AND 20 RESISTANT FLIES IN EACH GROUP

TIME IN HOURS	STRAIN OF FLY	μG. DDA APPLIED	TREATMENT OF FLIES BEFORE EXTRACTION	μG. DDA RECOVERED PER FLY		
				External	Internal	Total
18	Susceptible	10	Acidified	4.90	4.55	9.45
18	"	10	Not acidified	4.75	1.55	6.30
30	Resistant	5	Acidified	3.38	1.60	4.98
30	"	5	Not acidified	3.38	0.65	4.03

not acidified prior to extraction, indicate that DDA, after being absorbed, is converted to its salt in both strains of flies.

The inability of flies to degrade DDA rules out the possibility that DDA may be an intermediate transitory product in the metabolism of DDT by susceptible flies.

IN VITRO STUDIES ON DDT DEGRADATION

The foregoing studies suggested the desirability of an attempt to degrade DDT by incubation with various tissues of resistant and susceptible flies. Previous attempts to demonstrate the degradation of DDT with the whole fly *brei* of resistant and susceptible flies were erratic, in that occasionally considerable quantities of DDE could be obtained by this method from the *brei* of resistant flies, but the results could not be consistently reproduced. It is worth stating, however, that in all cases where the *brei* of susceptible flies was used, we were able to recover only DDT, and usually in theoretical quantities.

Various tissues of susceptible and resistant flies were dissected from the living flies and placed in 3 cc. of Kreb's ringer solution containing 2% glucose and buffered to a pH of 7.0. An amount of DDT in ethanol solution, approximating that which might be used on an equivalent number of flies, was then added to the Ringer solution. The amount of ethanol introduced was 5 mm.³ per 50 μg. DDT. These tests

were incubated in Warburg respirometers in order to maintain constant agitation and a temperature of 37° C.   The results of these preliminary attempts are shown in Table VII.

In several instances, the ethanol solution of DDT was applied directly to the sections of cuticle before immersion in Ringer solution for incubation.   By this method no degradation occurred even when resistant fly cuticle was used, and it seems likely that the cells were killed by the ethanol.   When the ethanol solution of DDT was added to the Ringer solution, and the DDT thus present as a fine suspension, degradation to

TABLE VII

RECOVERY OF DDT AND DDE FROM FLY TISSUES INCUBATED IN 3 CC. KREB'S RINGER PLUS 2% GLUCOSE, pH 7.0, WITH DDT IN SUSPENSION

SUSCEPTIBLE FLIES	μG. DDT ADDED	RECOVERED		TIME INCUBATED IN HOURS
		μg. DDT	μg. DDE	
10 abdominal cuticles.............	47	45	0.0	3
5 " "	19	18	0.0	26
5 " "	14*	12.8	0.0	26
RESISTANT FLIES				
10 thoracic cuticles...............	43	35.4	3.9	4
10 abdominal cuticles.............	45	42.8	3.5	4
10 " "	46	41.8†	0.8	7
10 " "	46	35.3	2.2	12
10 " "	46	37.7‡	3.5	18
50 " "	52	47.2	3.0	14
50 " "	54	44.7	8.9	17
10 " "	40*	36.5	0.0	12
10 " "	40*	37.5	0.0	12
10 digestive tracts................	25	27.0	0.0	12
10 brain and thoracic ganglion.....	25	25.0	0.0	12
5 puparia contents...............	49	48.5	0.0	4
50 abdominal cuticles centrifugate (mostly cuticle).............	88	89	0.0	20.5
supernatant (cellular disintegrates)......................	81	78	0.0	20.5

* DDT applied topically to the cuticle before immersion in Ringer.
† Cuticle and Ringer analyzed separately. 19.8 μg. DDT and 0.8 μg. DDE on the cuticle. 22 μg. DDT in Ringer.
‡ Same. 17.2 μg. DDT and 3.5 μg. DDE on cuticle. 20.5 μg. DDT in Ringer.

DDE by the cuticle-hypoderm of resistant flies could be demonstrated. The per cent degraded was in all cases low, only in one instance approaching 20 per cent of the total DDT present.   No tissues tested, other than the cuticle-hypoderm of resistant flies, have been found able to degrade DDT *in vitro*.   It should, however, not be concluded that other tissues cannot bring about the degradation of DDT, since the optimum conditions for *in vitro* degradation are not by any means known.   It is evident, though, that this resistant strain of fly does possess a mechanism in the peripheral region of the cuticle-hypoderm which can degrade DDT to DDE *in vitro*.

METABOLISM OF DDT WHEN APPLIED TO LARVAE

The larval stage of the house fly has been observed to be relatively more resistant to DDT than the adult. Larvae from our susceptible strain taken two days before reaching the normal date of pupation are capable of tolerating 10 μg. of DDT applied as a topical application. Larvae thus treated successfully enter the pupal stage, but rarely emerge therefrom, as adult flies. The same stage of larvae treated with 1 μg. of DDT applied topically will enter the pupal stage and transform to adult flies with the same survival as untreated controls. Larvae from our resistant strain when topically treated with 10 μg. of DDT at this

TABLE VIII

RECOVERY OF DDT AND DDE FROM RESISTANT AND SUSCEPTIBLE LARVAE AFTER TOPICAL APPLICATION OF DDT TWO DAYS BEFORE NORMAL DATE OF PUPATION. TEN LARVAE WERE ASSAYED AT EACH TIME INTERVAL

TIME IN HOURS AFTER TREATMENT	STRAIN OF LARVA	μG. DDT APPLIED	RECOVERED PER LARVA			
			External μg. DDT	Internal		Total* μg. DDT
				μg. DDT	μg. DDE	
1	Resistant	10	9.90	0.00	0.10	10.00
2	"	"	9.80	0.02	0.30	10.15
3	"	"	9.50	0.01	0.41	9.96
5	"	"	9.45	0.09	0.24	9.80
9.5	"	"	9.25	0.18	0.42	9.89
15	"	"	9.20	0.09	0.82	10.19
20	"	"	8.20	0.43	0.51	9.21
1	Susceptible	10	8.70	0.05	0.00	8.75
2	"	"	8.45	0.10	0.00	8.55
4	"	"	7.10	0.25	0.00	7.35
14	"	"	7.20	0.38	0.00	7.58
26.5	"	"	6.25	0.95	0.00	7.20
1	Susceptible	1	0.89	0.03	0.00	0.92
2	"	"	0.83	0.05	0.00	0.88
3	"	"	0.84	0.08	0.00	0.92
13	"	"	0.43	0.23	0.00	0.66
26	"	"	0.33	0.16	0.00	0.49

* Total recovery based on molecular weight of DDT.

stage successfully enter the pupal stage and emerge as adults with approximately the same percentage survival as untreated larvae. Thus it is apparent that the larvae of the two strains differ in respect to their tolerance to DDT.

Larvae of the two strains of flies were treated in the manner previously described and placed in petri dishes without food until they were extracted and assayed for DDT and its metabolites. The data from this experiment are summarized in Table VIII.

It is at once obvious that tolerance in the case of each strain is not due to the inability of DDT to penetrate the cuticle. The rate of

absorption of DDT by the larvae of both strains is in the same order or greater than that found by Sternburg *et al.* for the adults. There are several obvious differences between the two strains with respect to the metabolism of DDT. First, the resistant strain has the facility to convert DDT to DDE and store it in considerable quantity as such, whereas, not a trace of DDE is to be found in the susceptible larvae. Second, it is possible to account for near theoretical quantities of the DDT applied to resistant larvae 20 hours following treatment, while in the case of susceptible flies, there is a gradual and unaccountable loss of DDT as the time between treatment and extraction is extended. These

TABLE IX

RECOVERY OF DDT AND DDE FROM VARIOUS SOURCES OF RESISTANT ADULTS 6–8 DAYS AFTER TOPICAL TREATMENT OF THE LARVAE WITH 10 μg. DDT PER LARVA. TWENTY INSECTS PER GROUP

MATERIAL ASSAYED	RECOVERED PER INSECT			
	Group I		Group II	
	μg. DDT	μg. DDE	μg. DDT	μg. DDE
Rubbed off in flask..........	5.05	0.00	4.50	0.00
Empty puparium............	3.25	0.00	2.85	0.00
External on adult............	0.04	0.08	0.04	0.06
Internal:				
Cuticle...................	0.00	0.85	0.00	0.49
Brain and thoracic ganglion...............	0.00	0.00	0.00	0.00
Digestive tract and sex organs................	0.00	0.10	0.00	0.03
Thoracic muscles.........	0.00	0.10	0.00	0.05
Total..............	8.34	1.13	7.39	0.63
Total based on molecular wt. of DDT..............	9.59		8.09	

observations suggest that the susceptible strain of larvae possess a mechanism for metabolism of DDT into a product which does not respond to the Schechter test. The fact that resistant larvae do not show a comparable unaccountable loss may be due to their ability to convert DDT to DDE before it reaches a site where it would otherwise be converted to unknown metabolites. Evidence supporting this speculation is provided in Table V, where it was shown that neither strain possessed any marked ability to further degrade DDE in any reasonable interval of time after topical treatment.

Further evidence of the retention of DDE by resistant flies was shown by the following study, in which resistant larvae were treated topically with 10 μg. of DDT per larvae one day prior to pupation and then held until they became adults (6–8 days). Results of the analysis of these adults are shown in Table IX. In view of the number of manipulations

involved in the dissection process, the recovery of 80 to 95 per cent of the original dosage after 6–8 days had elapsed is extremely high, and it seems safe to assume that degradation beyond DDE has not taken place. Again, as in the dissection of topically treated resistant adults, only DDE was recovered from internal tissues of the flies, and the greater part of the DDE recovered appears to have been retained in the cuticle-hypoderm throughout the period of transformation. Since the amount of DDT absorbed was only that which would be absorbed by resistant larvae in approximately 20 hours (Table VIII), it appears that absorption after pupation must have been negligible. This observation led to the study of DDT absorption by puparia.

J   ABSORPTION AND METABOLISM OF DDT BY THE PUPARIA

In this study newly formed puparia of both strains of flies were given topical dosages of 10 µg. DDT per puparium, and then held 24

TABLE X

RECOVERY OF DDT AND DDE FROM 20 PUPARIA TOPICALLY TREATED WITH 10 µg. DDT PER PUPARIUM

STRAIN	TIME IN HOURS	RECOVERED PER INSECT			
		External µg. DDT	Internal		Total As µg. DDT
			µg. DDT	µg. DDE	
Resistant.......	24	8.80	0.52	0.46	9.83
"	48	8.02	0.26	1.20	9.61
Susceptible.....	24	9.3	0.25	0.00	9.55
"	48	8.45	0.45	0.34	9.28

and 48 hours before analysis for DDT and metabolite. The results obtained are summarized in Table X. No significant difference was found in the rate of absorption of DDT by the two strains. Absorption, however, is slow compared to that of larvae and adults, and even 48 hours after treatment over 80 per cent of the applied dosage can be recovered from the external surfaces. Resistant pupae possess the same facility to degrade absorbed DDT that is present in resistant larvae and adults, and the DDE formed is retained as such. Pupae of susceptible flies treated topically were found after 48 hours to contain some DDE. This is the first time we have recovered DDE from the susceptible strains after topical application of DDT. Since, as shown in the latter part of this paper, larvae of susceptible flies are able to metabolize DDT to DDE by means of the digestive system, it is possible that during the transformations occurring in the pupal stage, a substance normally present only in the digestive tract has been liberated into the body fluids and brought about the partial degradation of the dosage of DDT which was absorbed.

METABOLISM OF DDT WHEN FED TO LARVAE IN CULTURE MEDIA

It was observed that the larvae of resistant and susceptible flies transferred two days before their normal pupation date to larval media containing DDT responded differently to certain dosage levels. It was found that approximately the same percentage of adults could be obtained when resistant fly larvae were put in media containing 1000 p.p.m. as when susceptible larvae were placed in a media containing DDT at the rate of 100 p.p.m. The desirability of comparing the metabolism of DDT in the two strains and through the life stages, larva, pupa, and adult, when exposed to DDT in this manner seemed

TABLE XI

RECOVERY OF DDT AND DDE FROM RESISTANT LARVAE, PUPAE, AND ADULTS
PRODUCED FROM LARVAE THAT HAD FED 48 HOURS ON FOOD CONTAINING
1000 P.P.M. OF DDT. 20 LARVAE AND PUPAE PER TEST;
5 ADULTS PER TEST

| | RECOVERED PER INSECT | | | |
| | External | | Internal | |
LIFE STAGE	μg. DDT	μg. DDE	μg. DDT	μg. DDE
Larva	0.56	0.16	0.00	11.7
"	0.45	0.05	0.00	13.7
"	0.49	0.13	0.00	16.2
"	0.35	0.13	0.00	16.2
Pupa	0.61	0.21	0.00	17.0
"	0.79	0.34	0.00	18.8
"	0.54	0.27	0.00	19.5
"	0.38	0.27	0.00	18.7
Adult	0.00	1.60	0.00	6.8
Empty puparium	0.86	0.40		

apparent, since the two strains would presumably consume considerable DDT in the process of feeding for 48 hours.

After a 48-hour period of feeding in DDT-treated media, the desired number of larvae were selected from the culture, rinsed to remove surface DDT, and then assayed for DDT and DDE in the usual manner. The larvae remaining in the culture furnished pupae and adults for the other phases of the experiment. The pupae and adults used in these tests were 24 to 48 hours old when they were used. In other respects they were given the same treatment as the larvae.

The data obtained from these experiments are presented in Table XI, where the resistant strain was used, and in Table XII for the susceptible strain. It is assumed that most of the DDT and DDE found in the internal tissues of the larvae gained entry through the intestinal tract. This assumption is supported by the fact that sus-

ceptible larvae treated in this manner were found capable of converting some of the DDT to DDE, whereas topical doses of DDT to this strain do not give rise to DDE when absorbed (Table VIII).   If this is true it can be assumed that the intestinal tract of the larva of both strains may affect the conversion.   While the two strains of larvae are alike in being able to convert DDT to DDE they differ in the fact that only DDE is to be found in the internal tissues of the resistant strain; whereas, both DDT and DDE are found in the susceptible strain.   These data also indicate the greater capacity of the larvae of the resistant strain to degrade DDT.   The obvious difference between the amount of DDE found in the adult as compared to that found in the larval and pupal stages of the two strains may possibly be explained by the failure of

TABLE XII

RECOVERY OF DDT AND DDE FROM SUSCEPTIBLE LARVAE, PUPAE, AND ADULTS PRODUCED FROM LARVAE THAT HAD FED 48 HOURS ON FOOD CONTAINING 100 P.P.M. DDT.   25 INSECTS IN EACH LIFE STAGE WERE ANALYZED AS A GROUP

| LIFE STAGE | RECOVERED PER INSECT | | | |
| | External | | Internal | |
	μg. DDT	μg. DDE	μg. DDT	μg. DDE
Larva	0.43	0.00	1.88	0.94
Pupa	0.46	0.00	0.99	0.17
Adult	0.00	0.00	0.00	0.10

many individuals to pass through to the adult stage.   It is assumed that many of the larvae consumed a dose of DDT which proved fatal to them during pupation, thus those which reached the adult stage may have been only those which consumed the lowest dose in the larval stage.

SUMMARY

Resistant flies, in both larval and adult stages, are able to degrade oral dosages of DDT to the dehydrochlorinated compound DDE.   In the adults DDE formed in the digestive tract is liberated into the body tissues and accumulates for the most part in the cuticle-hypoderm. DDT as such does not pass from the digestive tract to other tissues.

Topical application of DDT to resistant larvae, pupae, and adults results in the formation of DDE in the cuticle-hypoderm.   When precautions are taken to prevent adult flies from sponging DDT-contaminated surfaces, no DDE or DDT is to be found in any part of the body except the cuticle-hypoderm where detoxification apparently occurs. DDE, once formed, is retained in the body and not metabolized further. Very little is excreted.   When resistant larvae are treated topically with DDT, it has been shown that the adults produced by these larvae contain DDE, mainly in the cuticle-hypoderm, and that almost complete

recovery of the original dosage can be obtained, partly from the empty puparia as DDT and the rest from the adults as DDE.

Topically treated adult susceptible flies, with their mouthparts removed to prevent ingestion of DDT, absorb DDT into the cuticle-hypoderm only. No DDT can be recovered from other tissues of the body. The DDT absorbed by the cuticle-hypoderm is partly metabolized to an unidentified substance not responding to the Schechter test. It is possible that this fraction of the dosage, not responding to the color test, may actually be responsible for the toxic action of DDT. Other alternatives are that DDT present in the cuticle-hypoderm causes a toxin to be produced by the cells, that is then carried in the haemolymph to the rest of the body, or that DDT acts directly on the peripheral nervous system without the aid of an intermediate toxin.

Larvae of susceptible flies treated topically give results similar to those found for the adults. When fed DDT, susceptible larvae possess a weak ability to form DDE. This ability to degrade DDT to DDE in the digestive tract is not developed to the extent found in resistant larvae, where degradation is complete even at higher dosage levels. It is evident, though, that the mechanism by which DDT is degraded to DDE is present to a certain extent in the intestinal tract of the susceptible strain of flies.

Neither DDE nor DDA can be metabolized by either strain of fly. Close to theoretical recovery can be obtained 20 hours or more after topical treatment, even though the greater part of the dosage has been absorbed by the insect. DDA that is absorbed is partly converted to its salt and as such is retained by the body. Thus neither of these compounds can be a transitory intermediate in the metabolism of DDT by susceptible flies to an as yet unidentified compound.

Puparia of both strains of flies are relatively impermeable to DDT applied topically in ethanol solution. Over 80 per cent of a 10 μg. dosage of DDT can be recovered 48 hours after application. The small amounts absorbed are converted to DDE by both strains; almost completely by the resistant strain, but only to a small extent by susceptible pupae. Susceptible pupae thus differ from their larvae and adults in this respect, since neither have been found able to form DDE after topical application of DDT.

In vitro studies have been made on various tissues of both strains, and although the optimum conditions are not yet known, it has been shown that the cuticle-hypoderm of resistant flies can degrade DDT to DDE *in vitro*. Other tissues have not yet shown this ability and in the case of susceptible fly cuticle no degradation can be demonstrated.

The data and results listed above lead to the conclusion that the cause of resistance to DDT by certain strains of flies is due to the development of a mechanism by which DDT is detoxified to DDE in the cuticle-hypoderm and in the digestive tract before it has reached a vital site.

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THE NEARCTIC LEAFHOPPERS (HOMOPTERA: CICADELLIDAE), A GENERIC CLASSIFICATION AND CHECK LIST, by PAUL WILSON OMAN. Mem. Ent. Soc. Washington, No. 3. 253 pages, 44 plates. 1949.

This is one of the most outstanding recent contributions to the study of one of the most difficult families of the Homoptera. Dr. Oman is due the deep appreciation of all students of leafhoppers for having made a thoroughgoing taxonomic survey of these insects.

The introduction covers the broader aspects of our knowledge of this family and includes an historical resume, problems of classification, life histories, host plants and food plants, economic importance, leafhopper vectors of plant virus diseases, parasites, distribution, technique, morphological notes, terminology, and bibliographic information.

This is followed by the taxonomic part. There is a key to the subfamilies. The subfamilies are treated according to a standard pattern with descriptions of the subfamilies, keys to the tribes, if necessary, descriptions of the tribes, and keys to the included Nearctic genera. The generic descriptions include complete bibliographic references to original descriptions and type designations and is followed by an alphabetic list of species with bibliographic citations to original descriptions, general distribution, and synonymy.

The specific synonymy seems to have been especially well handled.

The genus *Aphrodes* Curtis lists six species, five of which are Palearctic species that have been introduced into our fauna; but in this genus not less than thirty-six synonyms are listed. Yet in handling such a complex only two minor errors are apparent: *bicincta* Curtis is cataloged as a synonym of *costata* Panzer but is not listed among the synonyms of that species, and *testudo* Curtis is cataloged as a synonym of *costata* Panzer but is listed as a synonym of *albifrons* Linnaeus.

Another fundamental taxonomic problem fully recognized by the author is the proper definition and association of the subfamilies of the leafhoppers. While he believes that the group treated in this work as a single family with eighteen subfamilies will eventually be divided into several families, he does not believe that our knowledge has progressed far enough to enable one to do this successfully at this time.

No review of this contribution to knowledge would be complete without reference to the forty-four fine plates which include figures of the dorsal and facial and sometimes the lateral view of the heads and of the fore and hind wings of most of the genera.

There are also illustrations of the nymphs of some of the more common genera and a few illustrations of the genitalia. Having held for many years the view that the male genitalia could furnish more reliable generic characters than most of the structures now used to define genera, I cannot help but regret that this feature was not greatly expanded.

This contribution will find a place on the work table of every student of Nearctic leafhoppers. It could well serve as a model for the students of other orders of insects not only from our fauna but from all regions of the world.

Z. P. METCALF.

NEUERE PROBLEME DER ABSTAMMUNGSLEHRE, by BERNARD RENSCH. vii+407 pp., 102 fig. Ferdinand Enke Verlag, Stuttgart. 1947.

This interesting, well-documented, synthetic treatise, prepared by a foremost student of evolution, is of unique interest since, because of war-time limitations on communications it was written without access to the recent English-language treatises in the same general field including principally "Systematics and the Origin of Species" by Ernst Mayr (Columbia University Press, 1942), "Evolution. the New Synthesis" by Julian Huxley (Harpers, 1942), and "Tempo and Mode in Evolution" by G. G. Simpson (1945). All of these treat aspects of evolution discussed by Doctor Rensch. This affords an unusual opportunity to compare conclusions reached independently and based, in part at least, on different fundamental materials. Although there are some instances of disagreement, the reader cannot resist the impression of a rather remarkable concurrence in most aspects of basic philosophy. No reader can fail to be impressed favorably with the author's admirable capacity to employ a huge variety of materials and sources of information, an appreciable portion of which is entomological. Emphasis is primarily on trans-specific processes but as a basic introduction there is initially a concentrated review of the processes and factors involved in specific and intraspecific evolution with attention to the kinds and causes of mutations, random nature of mutations, pleiotropy and interaction of genes, fate of genes in respect to fluctuations in populations, and the mechanisms of natural selection. Naturally-occurring races (subspecies) are classified as (1) historic, (2) geographic, (3) ecologic, (4) sexual, (5) genetic, and (6) hybrid. Geographic races are believed to be the primary precursors of new species although ecologically, physiologically (sexually), and genetically isolating processes are usually also involved. Processes involved in speciation are regarded as the same as those in subspeciation and Goldschmidt's suggestion of chromosome mutations (in contrast to gene mutations) as basic to speciation is rejected.

Most of the book is devoted to a consideration of the adequacy of random mutation and natural selection as basic explanations for the processes involved in trans-specific evolution, and the many manifestations of these processes in terms of orthoselection, parallel selection, and allometric effects, to mention only a few. The development of most evolutionary series shows a *specialization phase* the extent of which is, to a certain extent, a function of the variety and relative saturation of biocoenoses. There are very interesting considerations of the basic phenomena involved in the development of certain structures at the expense of others (reconstruction). Allometric relations, pleiotropy, interaction of genes, and selection in terms of optimal utilization of energy and synthetic materials in ontogeny are to be considered. *Parallel structures*, such as similar wing patterns in different families of Lepidoptera, are to be explained basically in terms of the occurrence of homologous genes with orthoselection and/or the favorable selection of mimics of distasteful species. There is an interesting section (pp. 80–111) dealing with the absolute rate of evolution. Among the Arthropoda evolution has been more rapid in the terrestrial groups as is the case also among the Vertebrata. Present species may have evolved 100,000 to 500,000 years ago whereas recognizable geographic races have developed during recent historic times. Rate of evolution is a function of environment in terms of several ramifications, conditions for selection being probably the most important. "Predisposition" of existing structural plans makes the assumption of increased mutation rates during periods of rapid evolution unnecessary. However, increased mutation rate is offered as a possible explanation of the so-called explosive developmental periods such as that of insects during the Carbonaceous and Permian; development of new biotopes and other environmental factors are doubtless involved also. These are only the briefest and most fragmentary glimpses of a rich array of ideas and examples which can be appreciated only by careful scrutiny of the entire book. Of particular interest to entomologists should be the section (pp. 240–260) on the action of evolution on different stages in life cycles. The section (pp. 316–325) entitled "Die Evolution des Lebendinger" is perhaps the weakest. One raises the question of the advisability of an attempt to discuss such a complex subject, which should involve many biochemical physiocochemical and thermodynamic considerations, in nine pages. The concluding sections (pp. 326–373) are profoundly philosophical and probe deeply into the very fundamental causal precepts of biology and natural science.—DONALD S. FARNER.

OBITUARY NOTICE

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PERCY NICHOL ANNAND. On the morning of March 29, the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture, for the second successive time lost its active head through death. No doubt weakened by serious operations earlier in life, and further affected by the heavy burdens of his official work, Dr. P. N. Annand died from a heart condition at the age of 51, thereby depriving the Bureau of a leadership that should have been available to it for years to come.

According to official sources of information, Dr. Annand was born at Telluride, Colo., in 1898, was graduated from Colorado Agricultural College in 1920, worked for the Great Western Sugar Company in 1920–1921, was an assistant at Stanford University in 1921-2, where he received an M.A. degree in 1922, was head of the Biology Department of the San Mateo, California, Junior College from 1922 to 1929, during which period he studied also at Stanford University and received a Ph.D. degree in 1928. His first association with the Bureau came in 1929, when he joined its sugar beet leafhopper investigation project, working in the western U. S. for three years. Brought to Washington as assistant leader of the Truck Crop Insect Division in 1932, his obvious capabilities led him, in the brief period of the following nine years, through positions as head of the Cereal and Forage Insect Division, Special Research Assistant to the Chief of Bureau and Assistant Chief of Bureau for Research to Chief of Bureau in 1941.

While it is not the proper function of this notice to discuss or to evaluate Dr. Annand's services to economic entomology—such a review surely will be presented in the more appropriate vehicle which is available—brief mention of some aspects of his relation to this field seems permissible. Thus, in a day when opinion is sometimes voiced that insect taxonomy represents only a pioneering, and presumably primitive, phase of economic entomology, it is perhaps worth noting that Dr. Annand acquired his basic training in entomological research from a painstaking, critical study of the classification of the North American species of one group of insects (Adelginae). It may be noted, too, that Dr. Annand's leadership of the Bureau coincided with the greatly augmented entomological activity of the war period, with the outstanding development of a whole new group of insecticides and new methods of treatment for insect control, and with the need to meet new and critical problems in economic entomology, stemming in large measure from the war and its aftermath; problems, for example, so varied as those arising from the great increase in the rapidity and diversity of world transportation that followed the war, and from the marked increase in post-war international cooperation through United Nations and other agencies.

To all of the widely varied activities of the Bureau, old or new, Dr. Annand made the contributions consistent with his position as Bureau leader, displaying throughout his remarkable talent to absorb the smallest details of any problem, to correlate these details, to develop from them and to present a simple, clear, picture of the problem, from basic causal factors to probable ultimate solution. The success of his leadership is attested from many sources, but perhaps the strongest and certainly the most human evidence of this is to be found in the extraordinary outpouring of contributions from Bureau personnel and others when the time came to pay final floral tribute to the man and his work.

—HAROLD MORRISON.

NOTES ON THE BIOLOGY AND SOCIAL BEHAVIOR OF THE ARCHAIC PONERINE ANTS OF THE GENERA MYRMECIA AND PROMYRMECIA

CARYL P. HASKINS and EDNA F. HASKINS

Few groups of ants are so potentially interesting to the myrmecologist primarily concerned with phylogeny and social behavior in the Formicidae as the extraordinarily archaic ponerine tribe Myrmecii, composed of the large-eyed, generalized, actively stinging members of the genera *Myrmecia* and *Promyrmecia*. Yet despite the fact that the group has been known and recognized scientifically at least since the beginning of the last century, and despite the striking habitus of many species, very few extensive studies have been made on them outside those of Wheeler and of Clark.

There can be little doubt that the Myrmecii, together with one or two other tribes of ponerine ants such as the Amblyoponii and a few scattered genera among the Cerapachyinae, represent the closest approximation among living ants to the ancestral stirps of the Formicidae. Of these only the Myrmecii are so little specialized to subterranean habits, and retain so many features of structure and habit that are strongly suggestive of more generalized epigaeic solitary aculeates. Careful studies of social organization within such a group, both in the field and in the artificial nest, can hardly fail to be rewarding.

There seem to be few published studies of *Myrmecia* and *Promyrmecia* in the artificial nest to supplement the picture of their social organization obtained in the field. Wheeler was obliged to confine his studies of behavior very largely to the period of two expeditions to Australia, one made in 1914 and the other in 1931, which allowed little time for other than field work. Clark and his colleagues, while they have made numerous and striking observations upon the Myrmecii in the artificial nest over a long period, have not published correlations of these, so far as we are aware, and have necessarily been too thoroughly occupied with the task of constructing a logical taxonomy for the group, heretofore badly confused, to leave as much time for observational work as they would have wished.

Because of this dearth of published material upon the social behavior and habits of *Myrmecia* and *Promyrmecia*, it seemed desirable that
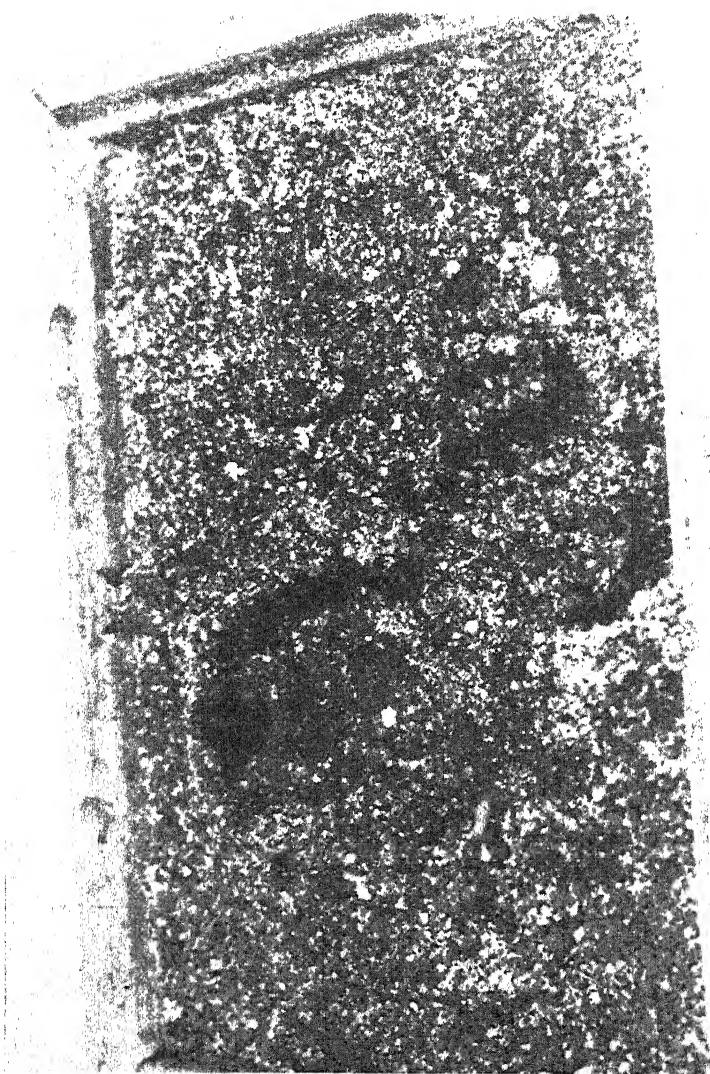
FIG. 1. *Myrmecia regularis.* Initial chamber of colony-founding female.

publishing excellent general habit notes of several species, also described
the nuptial flight and the general method of colony foundation in certain
of them—a subject of very great importance to an understanding of the
origins of social life among the Formicidae. Wheeler, in addition to
his very great contributions to our knowledge of the behavior of the
Myrmecii in general, was the first to fully outline the concept of an
intermittently claustral method of colony foundation, earlier suggested
and described by Clark, and to point out its very great significance as
an evolutionary step in the development of formicid societies. This
concept is of major significance. It will be expanded below, and
confirmatory data will be presented.

General Features of Colonial Structure

The colonies of most species of *Myrmecia* and *Promyrmecia* contain
but a single fertile female, far less strikingly differentiated from the
worker caste than is usual in the higher Formicidae. In a few species,
however, the colonies may be pleometrotic. This is notably true of
Promyrmecia pilosula in which Wheeler (1933) reported finding as many
as four females in a single colony. This was amply confirmed in the
present study. Thus, of eight colonies of the species examined at
Mt. Kosciusko, seven contained more than one fertile female and one
contained no less than thirteen. The fertile females from this colony,
housed in the artificial nest, have continued to co-operate actively in
colonial functions for more than a year.

The eggs of the Myrmecii are proportionately large, varying from
about 1 mm. to 1.5 mm. in the longer axis. Unlike those of other ants,
they are subspherical in form, and, in most species, are not agglomerated
into packets, but lie scattered singly in the brood-chambers. In *P.
pilosula* and possibly a few other species, there is occasionally some
indication of the formation of an egg packet, so characteristic in the
higher ants. When the nest is disturbed, each egg is carried away to
safety individually by the active and aggressive workers.

The young larvae, in contrast to the eggs, are markedly adhesive,
and during earlier instars are agglomerated into packets. The larvae
are fed with pieces of whole insects, brought into the formicary by
foraging workers and distributed among them. The adults among all
the Myrmecii are highly nectarivorous in habit. Insect food is taken
by adult workers, but only rarely and sparingly when larval brood is not
present in the nest, and little or no insect food is brought into the
formicary at this time. As soon as young larvae have appeared, how-
ever, the change in the food habits of the adults is very striking. Insect
food is now taken extensively, and, among the more active species, a
constant stream of prey pours into the nest, to be avidly licked by the
nurses and distributed among the larvae. As soon as the majority of
the larvae become enclosed in cocoons, the food habits are again
abruptly shifted. The co-ordination is not absolute, but is strikingly
close in many species.

The pupae of all known species of the Myrmecii are enclosed in
cocoons, which are usually thick and tough but do not differ markedly
in structure or appearance from those of higher ants. They are stacked
and tended by the adult nurses as among the higher ants. In their

Fig. 2. *Myrmecia vindex.* Colony-founding female in initial chamber.

manner of eclosion these cocoons differ significantly from those of higher ants, in a manner to be discussed below.

Such is the very general character of colonial structure among the Myrmecii. Superficially it is not strikingly different from that which obtains among higher ants. It is in what might be called the "fine structure" of colonial organization and behavior that differences of great interest, and probably of great evolutionary significance, appear. A number of these will be discussed below.

RELATIONS BETWEEN ADULTS, AND BETWEEN ADULTS AND YOUNG

In no group of ants, perhaps, are the social relations among the members of the colony at a more primitive level than among the Myrmecii. An equal simplicity is to be found in the Amblyoponii and among some of the Cerapachyinae, but in the Myrmecii alone extreme simplicity of basic colonial structure is combined with a rather high degree of over-all colonial organization apparently at variance with it.

It is characteristic of all the known species of *Myrmecia* and *Promyrmecia* that regurgitation of the ingluvial contents of the crop is impossible in the adult female and worker. This situation not only precludes ingluvial feeding of the larvae, so universal among higher ants, but also makes any direct exchange of nutriment among adults an impossibility. Only two cases have been seen among hundreds of observations made in the artificial nest in which there was any indication of the power to regurgitate. In one instance a worker of *M*. tarsata, grasped by the thorax with forceps when full-fed with honey, exuded a droplet on the labrum. In the other, a worker of *P. pilosula* (with little doubt the most highly socially organized species of the Myrmecii) was observed in the artificial nest to align itself with an individual which had been feeding on dilute honey and to avidly lick its mouthparts. It seems likely, however, that this movement did not involve regurgitation of crop contents, but was simply designed to avail the solicitor of excess honey adhering to the mouthparts of the feeding individual. With these two dubious exceptions, no evidence of the possibility of transfer of food from individual to individual has ever been detected.

The phenomenon of trophallaxis, first defined by Wheeler (1910), and, as he pointed out, one of the most powerful social bonds among higher ants, is thus largely wanting among the Myrmecii. It should be added, however, that the larvae apparently produce abundant dermal exudates when fed insect food, as do those of the higher ants, and these are avidly licked by the adults. This licking of the larvae commences almost immediately after they are hatched and is continued throughout larval life. It has been observed in the artificial nest in colonies of all the species examined, and among isolated colony-founding females with their very young broods in *Myrmecia forficata* and *M. vindex*. It is peculiarly interesting that the characteristic "soliciting" movement of the forelegs, closely associated with the supplication for ingluvial food among adults of the higher ants, is also well developed in *Myrmecia* and *Promyrmecia*, but here appears predominantly when adults are rasping the larvae for exudates. It thus appears, among these socially primitive forms, to be only a general excitatory reaction

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without specific social significance. This conclusion is of interest in view of the very similar interpretation of Maier and Schneirla (1935, p. 171) of the corresponding movements in very young callows of the higher ants, before they have taken on stereotyped social implications and functions. It is also of interest that adults, when licking the larvae, characteristically pinch and pull them, especially about the thoracic segments, in an evident effort to assist the flow of exudates—a procedure strikingly reminiscent of the habit among the nurses of such primitive social vespine genera as *Polistes* of pulling the larvae half way out of their cells and jamming them back, in an attempt to stimulate the salivary flow. This procedure of pinching has been seen even among colony-founding females of *Myrmecia forficata*, applied to very young larvae apparently far too fragile to endure such treatment.

It follows from these observations that the relationship between adults and young, as well as among adults, is far less stereotyped, far less socially evolved, and far less finely "modulated" among the Myrmecii than is the case among the higher ants. Thus the larvae, although licked and attended fairly continuously, often make their own way largely unassisted to the insect prey which is brought in by the nurses and scattered among them, and feed on it as opportunity offers, after the manner of the larvae of solitary sphecoids feeding on the paralyzed prey which has been left with them. The larvae of *Myrmecia* and *Promyrmecia* possess unusually well-developed body musculature and powerful mandibles, and have considerable powers of movement. They often attack, and not infrequently kill and devour, one another, especially when insect prey is scarce, and they have been seen to attack the adult nurses in the artificial nest.

The most finely adjusted behavioral patterns between adults and young are probably those which obtain at the time of the spinning of the cocoon by the larva on the one hand, and the eclosion of the pupa on the other. At the time that the larva is ready to spin the cocoon, it is regularly covered rather thickly with earth by its nurses, the particles of debris serving as anchor-points for the silk. This "banking" process is critical in the life of the larvae, for if it is neglected no cocoon can be spun and the young ordinarily perish. The process has been observed, under natural conditions or in the artificial nest, in many species, including *M. tarsata*, *M. gulosa*, *M. forceps*, *M. vindex*, *M. nigrocincta*, *P. piliventris*, and *P. pilosula*. As soon as the cocoon has been completed, it is removed and cleaned by the adults so that, in most species, no earth particles are left adherent. Among some species, which frequently nest in pure sand, however, notably *M. vindex*, this cleaning is very imperfect, and the cocoon is characteristically thickly studded with silica granules.

In the behavior of the adults toward the cocoon at the time of eclosion of the pupa, the Myrmecii exhibit an extremely interesting transitional stage in the evolution of intracolonial relationships. Among higher ants, the habit of adult workers of rendering extensive assistance to the young individual in escaping from the cocoon is so firmly fixed that without it the pupa is unable to emerge. Typically, among formicine ants, the cocoon is opened from the outside, the pupa is extracted before the pupal skin is shed, the skin is subsequently removed

by the attendant nurses, and the wings of the sexual forms are expanded. The young insects are extremely soft, callow, and helpless when first eclosed and it is usually several days before they harden and become capable of much movement. The work of Schneirla and others has indicated that it is predominantly during this relatively quescent period that many "learned" reactions are acquired and fixed which fit the young individual more perfectly to its social environment.

Among such socially primitive forms as the Amblyoponii the situation is almost exactly opposite. The pupal skin of the emerging adult is shed within the cocoon, the wings, if it is a sexual form, are expanded, and only thereafter the young insect itself gnaws open the cocoon and emerges. Characteristically, the young males are fully pigmented on emergence and capable of leaving the nest to fly within a few hours, and the young perfect females and workers, although somewhat callow, are able to assume active colonial duties almost immediately. Thus, incidentally, the only period of the life of the adult in which "plastic" adjustments of the individual to its social environment occur at all readily is passed in the cocoon by the young workers of the Amblyoponii, and, in a social sense, is "wasted." This situation was reported by Wheeler in *Stigmatomma pallipes* many years ago and has been amply confirmed by the authors in this species (1928) and more recently in *Amblyopone australis*.

The situation in *Myrmecia* and *Promyrmecia* in this respect has long been uncertain. It has been an open question whether young members of the colony normally emerge from the cocoon without active assistance from the workers, and whether they emerge in a callow or in a fully pigmented condition. Observations made in the course of this study on *Promyrmecia pilosula* and *P. piliventris* and *Myrmecia forficata* and *M. vindex* appear to give a definitive answer, at least for these species, and to indicate a most interesting state of transition in this aspect of intracolonial relationships.

Numerous cocoons of *P. pilosula* were isolated shortly before they were due to hatch. Some of these had been collected in the wild, others were from larvae reared in the artificial nest. The course of development was the same in all cases. Eclosion was delayed beyond the usual time, the pupal skin of the young imago was shed in the cocoon, and the adult advanced to full pigmentation and full activity. At this time, strenuous efforts were begun to escape from the cocoon. A hole was made and the mandibles were extruded. As soon as this happened, however, further progress became difficult since the cutting edges of the long specialized mandibles no longer made efficient contact with the cocoon. At this stage, about half of the individuals failed to progress further and ultimately perished. The remainder emerged successfully. They were fully pigmented and essentially adult. Cocoons of *M. forficata* similarly isolated uniformly failed to produce emergence, although a female of *M. vindex* succeeded in escaping without assistance.

It seems clear that such independent eclosion, though sometimes possible, is not the typical course. This was first indicated by the high proportion of extremely callow individuals found in the nests of all the species of *Myrmecia* and *Promyrmecia* examined at the appropriate

season, including *P. pilosula*—individuals in a far less developed state than those emerging from *P. pilosula* cocoons held in isolation. Observations of the behavior of the nurses of *P. pilosula* with cocoons undergoing eclosion in the artficial nest disclosed what appears to be the normal eclosion process, at least in this species. At the time that the cocoon is ready for eclosion, pupal movements excite the nurses and draw their attention to it. They cluster about the anterior pole, pulling and biting at it. At the same time, the mandibles of the young ant make a small hole and protrude through it. As soon as this occurs, the mandibles are seized by the attendant workers, and, using this projection as a brace, the cocoon is quickly torn away and the young ant is extratced by the nurses and licked profusely. Though callow, the pupal skin has already been shed, and the young adult is ready to assume colonial functions in a relatively shorter time than among the higher ants, though considerably longer than with the Amblyoponii. The Myrmecii, therefore, seem to be intermediate in this respect between the independent hatching characteristic of *Stigmatomma* and *Amblyopone* (where, nevertheless, the nurses commonly pay great attention to the cocoon undergoing eclosion and may occasionally open it, although their services are not required) and the obligatory dependence of the young emerging individual on its nurses which seems to be universal among all the higher ants with enclosed pupae.

It is interesting that, both in *Myrmecia* and *Promyrmecia*, the adjustments between adults and young inherent both in the banking of the larvae preparatory to spinning and in the release of the young imago appear to be much more labile and susceptible to disturbing influences of the outside environment than in higher ants. Thus, in the artificial nest, it is very usual for nurses of species of both *Myrmecia* and *Promyrmecia* to fail to bank the larvae at the proper time, even though they have successfully reared them from the egg, and to destroy the naked semipupae when these are formed. Similarly, it was very common, among all the species studied in the artificial nest, for nurses to cut open healthy cocoons prematurely and to extract the not yet mature pupae and destroy them. So troublesome did this become in several colonies that special precautions were necessary to ensure the rearing of normal broods.

As already indicated, relations among adults in *Myrmecia* and *Promyrmecia* are more tenuous and crude than among the larvae. Deportation of adult workers by other workers is very rarely seen. When it is undertaken, it is an awkward affair, without any standardized form, very unlike the sterotyped pattern of behavior common among the higher ants. Such deportation has never been observed outside of the artificial nest, and here it has been confined to aged or ailing individuals, so that it is questionable whether it ever occurs normally. It has not been seen in continuous observations of populous and thriving colonies of *Myrmecia tarsata* and *M. nigrocincta* in the artificial nest, observations extending in aggregate over two years, nor has it been detected in undisturbed colonies in the field.

Deportation of males, of young callow workers, and of old dealate females, however, does occur occasionally when the nest is disturbed. The deported individual is normally grasped by the mandibles or, in
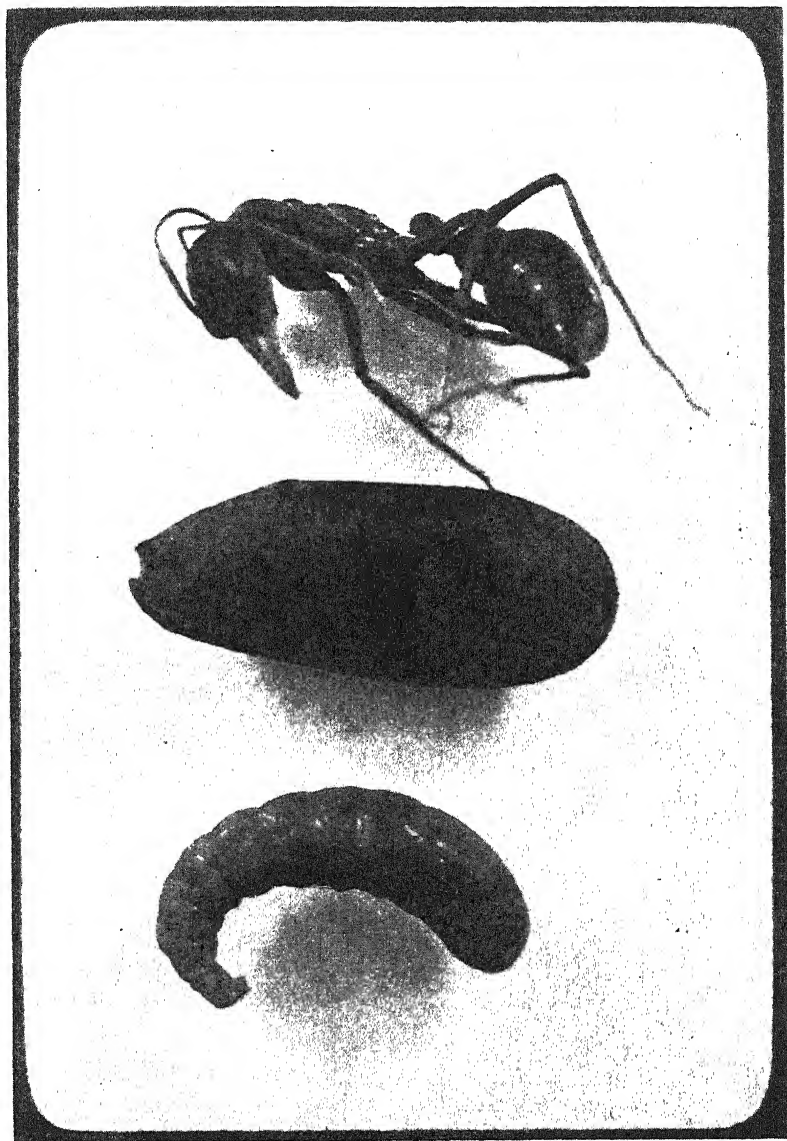
FIG. 3.   *Promyrmecia pilosula.*   Adult worker, cocoon, and larva.

the case of males, by the antennae, and pulled forward, the deporting individual running backward. The deported individual is never lifted from the ground, and shows no evidence of the tonic immobility or the standardized "deportation attitude" so characteristic of many species of higher ants. It is dragged, often with much resistance, to shelter.

PATTERNS OF COMMUNICATION AND OF FORAGING

The exceedingly low degree of inter-reaction among adult workers of the Myrmecii and the absence of the habit of exchange of ingluvial food lends a curious crudity to inter-individual relationships and to the foraging pattern. Within the nest, adult individuals occasionally rasp one another for surface accumulations, and this may take place upon any part of the body, including the mouthparts. During this time the excitatory motion of the forelegs is in evidence, but has none of the solicitory significance that it carries in higher ants. The individual being rasped becomes immobile during the process. This is essentially the only intimate relation between adults that has been observed in the field or in the artificial nest. All other behavior of the workers seems to be of purely individual character.

During the time that larvae are absent in the formicary, the adults are predominantly nectarivorous, as mentioned above, and little or no insect food is brought within the nest. At such times, individual workers forage alone for nectar, and do not tend particularly to return to the nest when the crop is filled. In this, as in other aspects of foraging behavior, the pattern is in the sharpest possible contrast to that of virtually all the higher ants. When larvae are present, the workers forage individually for insects and other arthropods, and, among the larger species, occasionally for larger forms of life. These are caught with much rapidity and dexterity (honeybees, for example, are a favorite prey of *M. gulosa* near Sydney and other large ants are frequently taken), are paralyzed or killed with the sting, and are promptly brought within the formicary. Here they are deposited near the brood, and licked briefly before the workers again set out for additional prey. No co-operation between individuals in securing insect prey has ever been seen in the field or in the artificial nest. Food particles from which all available nourishment has been secured are carried to the kitchen middens by any individual that happens to be near.

The total lack of co-operation in foraging was well illustrated in a series of experiments conducted both in the field and in the artificial nest. Those in the field were typical. Two populous colonies of *Myrmecia gulosa* were selected for the work, located near Sutherland, N. S. W. The work was done on January 12 and 13, 1948, at a time when most of the brood of these colonies was in larval form and seasonal foraging was at its height. Observations during the two days were begun in the morning, at 10:55 a. m. and 10:15 a. m. respectively, and continued until late afternoon, respectively 4:20 p. m. and 4:00 p. m. The air temperature at the beginning of the first day was 17.0° C., and within the mounds, six inches below the surface of the soil, was 17.5° C. It rose toward noon and then slowly decreased, reaching a low point of 16.0° C. of air temperature (although the nest temperature was 20° C.) at the end of the second day, when the sky was overcast and rain had

begun. During these periods, individual ants in a continuous stream were leaving on foraging expeditions over a half-mile radius about the nests, and were returning laden with insect prey of all sorts.

The experiment consisted in placing plastic cups filled with a mixture of honey and water thirty inches from the nest craters. These were shortly accidentally discovered by individual workers, which fed at them until the crops were distended. The first six individuals to feed were in each case marked with a small dot of nail polish, the individuals being distinguished by various colors of nail polish and by various positions of the mark. In most cases it was possible to mark such individuals while feeding without disturbing them. When the six
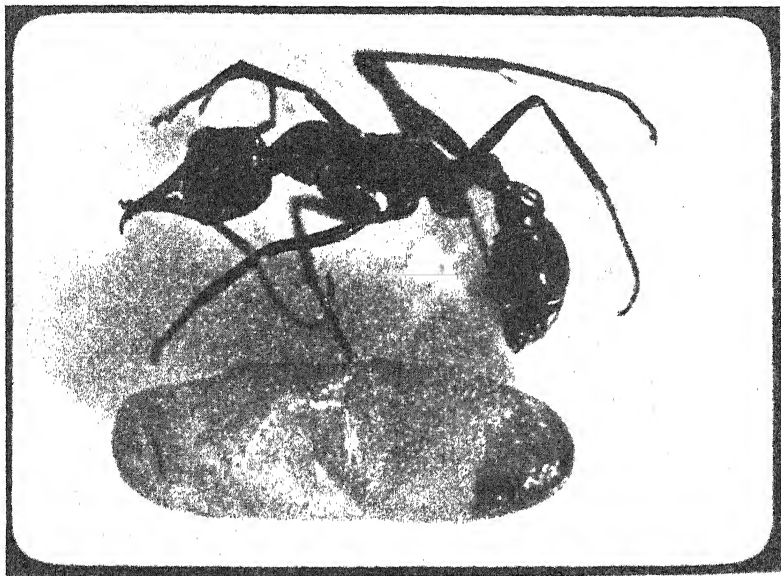
Fig. 4. *Myrmecia nigrocincta.* Adult worker and cocoon.

individuals of each nest had been marked, all ants subsequently finding the honey by chance were imprisoned, and observations made on the marked workers at five- to ten-minute intervals throughout the days.

In all, 132 observations were made of the behavior of such marked individuals in the two nests. The results were singularly stereotyped and uniform. In each case the forager, after feeding, showed no immediate tendency to return to the nest. In somewhat over half the cases, however, it entered the nest within two minutes of feeding. Foragers occasionally remained within the nests after feeding as long as one hour, but usually emerged again within a much shorter interval and returned to feed at the cups. The return was executed rather directly once an initial conditioning had been established. Orientation was evidently accomplished virtually entirely by vision, since the antennae were carried aloft during the whole process. *At no time during the*

entire experiment was a returning forager accompanied by other workers.
Nor was there any evidence whatever of a tendency of other workers to
follow an odor train to the cup, either of their own or another colony.
Unmarked workers which found the honey did so entirely by chance,
and were imprisoned.   There was not the slightest indication that
foraging workers of *M. gulosa* ever guide additional workers to the sites
of food that have been discovered—a situation at striking variance with
that in the higher ants.   There was never even indication of a general-
ized excitement within the nest caused by the entry of workers which
had discovered a particularly rich source of nourishment.   Each ant
was, in effect, walled off from its fellows.   Similar experiments with
communities of *M. tarsata* and *M. nigrocincta* in the artificial nest have
been confirmatory.

This striking inability to communicate stimuli from one individual
to another by any means was, in fact, a prominent characteristic of all
the species studied, and probably characterizes the entire group.   The
Myrmecii do not possess specialized stridulatory mechanisms com-
parable to such Ponerine genera as *Paraponera* or *Leptogenys*, nor do
they set up warning vibrations by any of the numerous secondary
means so usual among higher ants, such as striking the walls of chambers
and galleries with the head or gaster.[1]   This lack of communication
was strikingly exhibited when the nests of all the species studied were
being excavated.   When excavation is begun, workers in the superficial
galleries push out excitedly to attack the intruder.   The alarm spreads
through the nest only very slowly, however, and as each lower chamber
is uncovered it is found to be filled with workers which have not yet
been aroused by the disturbance above.   This situation was particularly
evident in excavating the nests of such large species as *Myrmecia
vindex, M. gulosa,* and *M. tarsata.*   It was as true at the height of
midsummer foraging activity as at any other time.   This is a strikingly
different behavior pattern from that of higher ants.   If colonies of the
larger *Myrmecias* exhibited anything approaching the degree of inter-
individual communication or co-ordination common among the higher
ants, they would be far more difficult to excavate than is the case.

COLONY RECOGNITION, AND "POLARITY" OF THE COLONY

Colonies of *Myrmecia* and *Promyrmecia*, like those of *Amblyopone*
and *Stigmatomma*, are extremely intolerant of the intrusion of alien
insects.   This intolerance extends to alien members of the same species,
which are quickly detected and killed or ejected from the nest.   Alien
eggs, larvae, or cocoons of the same species are readily accepted, but,
unlike the situation among many formicine ants, the adults developing
from them are, with very rare exceptions, detected as aliens and expelled
within a few hours.   Conditioning of workers to the new stimuli pre-
sented by alien adults of the same species maturing within the nest

[1]It has been observed, however, that young colony-founding females of *Pro-
myrmecia piliventris* may execute rapid rubbing motions of the second and third
gastric segments when excited by food, and careful microscopic examination of
the dorsal surface of the third gastric segment near its anterior margin reveals a
very slight specialization of the surface contours toward regular striae in that
region.

occurs very seldom indeed, whereas it is of course a common phenomenon among higher ants.   It is difficult not to speculate whether this phenomenon may be connected with the relatively advanced condition of the adult at the time of hatching from the cocoon, already described.

The situation indeed is more extreme than this.   There is considerable evidence that, unless all the members of a given community are in relatively continuous contact, schists will develop so that the members of one portion of the colony may become permanently hostile to the rest.   Two interesting bits of evidence concerning this situation were secured.

A large colony of *Myrmecia tarsata*, containing somewhat over five hundred workers and a very large brood, including many sexual pupae, was excavated with its single more or less physogastric brood queen. This queen was isolated, for purposes of transportation, with three adult workers and two cocoons, while a rather large sample of adult workers was placed in a separate container.   These two samples were kept isolated for four months, at the end of which period an attempt was made to recombine them in an artificial nest.   It was then discovered that, although the fertile female was readily accepted by both groups of workers, the worker groups themselves had become as hostile as though they had been drawn from separate colonies, and remained so permanently.   It seems probable that odor played an important part in conditioning this reaction, as among higher ants.   It is not clear from this case, however, whether individual differences of odor, such that each member of the colony must be continuously reconditioned to all of its fellows, are responsible, or whether each individual, in the course of its life-cycle, undergoes progressive odor changes to which its fellows must be continually re-accustomed.   In either event, it is remarkable that it seems to be necessary for every ant of a colony of *Myrmecia* to encounter every other colony member fairly frequently if the integrity of the social structure is to be preserved.   Such a requirement must put a sharp limit on the size which such communities can attain, and upon the possible degree of ramification of the nest.

The second bit of evidence in this connection strongly suggests that progressive changes in the odor of individuals with advancing age may be important, and that significant changes may occur in less than a month.

A relatively large colony of *Myrmecia nigrocincta*, in which nearly all the brood had already matured, was excavated, with its fertile brood-queen.   As in the previous case, this queen was isolated with some ten mature workers for transportation, the remainder being placed in a separate container.   Two weeks later the workers were colonized in an artificial nest, and the fertile female with the ten attendant workers were introduced.   It was then found that the workers already within the formicary now reacted hostilely to the ten workers and to the fertile female, with both of which they had consorted amicably less than fifteen days previously.   Both the fertile female and the workers were quickly killed by the remaining colony personnel.   It should be added that, both in this instance and in the preceding one, the isolated colony fragments were treated with great care, and that particular precautions were taken not to contaminate either fraction with foreign odors (as by handling) either during the period of separation or at reunion.

Thus it seems evident that a mature community of *Myrmecia tarsata* or *M. nigrocincta* (and probably of other species also) is a more or less constantly inter-communicating body, despite the very low degree of inter-reactivity among its members, and that if barriers to such communication are imposed, the relatively feeble influences which tend to maintain the integrity of a single colony quickly disappear.

SPECIALIZATION OF FUNCTION AND STRUCTURE AMONG WORKERS

Since the Myrmecii possess no means of distributing ingluvial food from one individual to another, nor of storing ingluvial food within the colony, opportunities for any great evolution of specialization of social function among the workers would appear to be sharply limited. During the brood-rearing season, to be sure, a constant supply of insect prey is brought into the nest and is available for the nourishment of adults which may not emerge to forage. The large supplies of larvae, also, serve as a potential source of nourishment through their exudates. This situation creates an ecological "niche" within the colony for a sedentary, non-foraging "nest" caste, such as apparently occurs among so many of the polymorphic higher ants. Among most if not all the Myrmecii, however, this situation is relatively temporary. Foraging for insects, as already indicated, drops off very sharply as the brood is matured, and in the fall and winter almost ceases among many species. It is probable that a few overwintering larvae remain in the nest, but the supply must be small—too small, it may be presumed, to serve as the entire source of nourishment for very many individuals, especially as the destruction and actual devouring of eggs or larvae apparently occurs much more rarely among the Myrmecii than in higher ants. Under such conditions, it would seem imperative that each individual worker leave the nest at intervals to forage for its own sustenance.

This is a difficult matter to test, but experiments with marked individuals of *M. nigrocincta* in the artificial nest have suggested that all the members of a given colony probably do emerge at more or less frequent intervals to seek ingluvial food, although the frequency of emergence varies greatly from individual to individual. It seems improbable that there is any specialized "brood" caste which remains permanently within the nest, or is regularly dependent on food brought in from outside by other foragers.

Consistent with this picture, the workers of most species of *Promyrmecia* are essentially monomorphic in form, and this is true of some species of *Myrmecia*, such as *nigrocincta*. In the majority of *Myrmecia* species, however, the workers exhibit a rather high degree of variability in stature, although very little in terms of bodily proportions. The largest workers may be somewhat more than twice the size of the smallest ones. It is true also that the smallest individuals, on the whole, tend to be less aggressive than the larger ones, and are more often found among the brood pile when the nest is excavated. There are numerous exceptions to this, however, and aggressive smaller individuals have occasionally been found foraging in several species studied in the field.

It is clear that this high degree of variability of worker stature provides a physiological basis for the differentiation of incipient castes. It seemed worth while to investigate more fully the extent to which such

size classes have become segregated to form distinct caste groups in at least one of the larger species of *Myrmecia* which shows typical variability in worker stature. For this purpose, an unusually large colony of *Myrmecia gulosa*, located near Sutherland, N. S. W., was selected, and its worker personnel were collected as completely as possible on
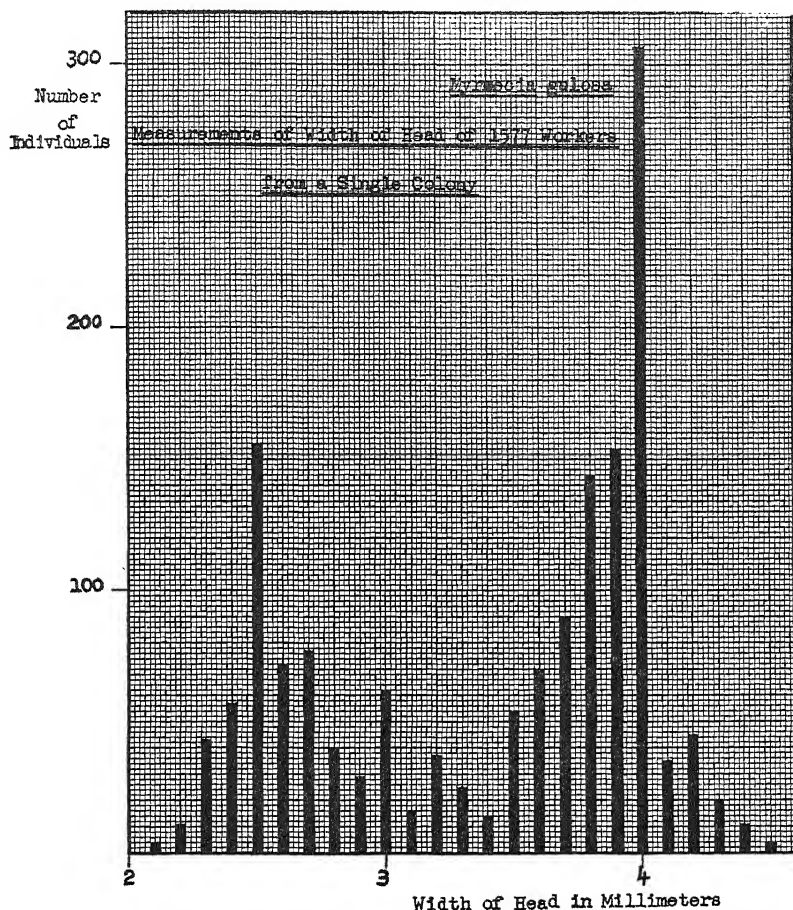
FIG. 5.   *Myrmecia gulosa*.   Measurements of width of head of 1577 workers from a single colony.

March 22, 1948, near the close of the brood-rearing season. Measurements were taken of the width of the head, viewed dorsally through the points of highest convexity of the compound eyes, of all the workers. This measurement was selected as a practicable criterion of the form and discreteness of size-classes because of the relative uniformity of bodily proportions which is characteristic of *M. gulosa* (as well as other variable species of *Myrmecia*) from workers of smallest to those of

largest stature. It may be added that this colony was one of the two upon which the experiments in communication and foraging behavior described above had been made two months earlier, when it was at the height of its larval-rearing period. During those observations, only members of the larger size-classes had been seen foraging. Several individuals marked with nail polish at that time were found inhabiting the upper galleries and chambers of the nest when it was excavated.

Head measurements were taken of a total of 1577 workers from this colony. The size-classes are shown in the accompanying plot, following the approach used by Weber (1946) and by Cole and Jones (1948) with *Oecophylla*. It will be seen that, in contrast to the situation in that Formicine ant, the size-classes are by no means clearly separated, but overlap very considerably. At the same time, several frequency modes are very clearly evident, suggesting the beginning of an evolution toward polymorphism. Also, the highest peak falls in the region of larger head-size, suggesting that the smaller classes have, in general, been derived from the larger ones that are nearer the stature of the perfect female. It is interesting to speculate whether any further evolution toward polymorphism could take place in the absence of some mechanism for the storage and the distribution of ingluvial food within the nest.

It is interesting further to notice that the variability of stature of the workers of *M. gulosa* seems to be relatively independent of trophic conditions in the colony. Thus the examination of this colony was made at the end of a period of several months during which conditions of temperature and nourishment had been optimum for maximum growth among the larvae. Yet one individual of the very smallest size class obtained (2.2 mm. head width), six of a head width of 2.4 mm., and one of 2.5 mm., were callows newly emerged, indicating that these size classes were probably being produced quite as abundantly, in terms of their normal proportion of the total population, as the larger classes during this optimal period. It seems likely that the causes underlying this variability are basically genetic and physiological rather than nutritional in nature, being related, possibly, to the varying penetrance of gene-complexes characteristic of the species.

NUPTIAL FLIGHT, MODE OF COLONY FOUNDATION, ROLE OF FERTILE FEMALE IN INCIPIENT AND MATURE COLONIES

A vivid description of the nuptial flight in one of the larger species of *Myrmecia* was given as early as 1882 by Tepper in the reference already quoted. It has since been described by Froggatt (1915), by Wheeler (1916), and by Clark (1925-7, 1934a).

The accounts of Tepper, Froggatt, Wheeler, and Clark all refer to the larger species of *Myrmecia*, such as *M. pyriformis*, *M. nigriscapa*, *M. gulosa*, *M. forficata*, and *M. sanginea*, in which the females are fully winged and in which an active flight takes place. The nuptial flight of these species may sometimes occur as a spectacular, "mass" affair, many hundreds of young queens and males emerging simultaneously, and the females being fecundated on bushes or other supports by the active, low-flying males, somewhat after the manner described for *Stigmatomma pallipes* (Haskins, 1928), though far more conspicuously.

It is clear, however, that this pattern of the nuptial flight is not universal in *Myrmecia* and *Promyrmecia.* In a number of forms, such, notably, as the beautiful brown-violet species *Myrmecia regularis* of southwestern Australia, the thorax shows a variable but decided reduction in size, and the wings are abnormally short. This same shortening of the wings obtains among the females of *Myrmecia nigrocincta*, *Promyrmecia piliventris*, and certain other species.

Two series of observations made in the course of the present study strongly indicate that the nuptial flights in such species are aberrant, and that the female, although emerging from the parent colony before fertilization, flies little, or not at all. In the first study, a colony of *Promyrmecia piliventris* in the artificial nest, containing numerous young females and males hatched from cocoons taken in the wild, was returned to the site of capture and opened, permitting the emergence of the winged forms, which shortly took place. It was thus possible to witness an "artificial" nuptial flight, as it were, taking place under essentially natural conditions. A male emerged from this nest in the middle forenoon of January 12, 1948, a clear and sunny day. After running about for a few moments it took flight and disappeared. It was followed by a short-winged female, which exhibited markedly positive phototropism and geotropism and, after running along the ground for a few moments with actively buzzing wings, but without taking flight, mounted a small shrub to its tip. Here, after feeding briefly on the exudates of a colony of aphids, the female became quiet, extending and curving the gaster and rubbing the posterior segments with the hind legs. This pose was maintained for approximately a minute, after which the insect slowly descended to the ground, exhibited reversed phototropism, and was returned to the artificial nest. Although no males appeared, this procedure was so very similar to that described in *Stigmatomma pallipes* (Haskins, 1928) as to strongly suggest that in this species, and probably in others in which the wings of the female are short, fertilization is normally accomplished on the ground or on bushes by the active, low flying males, and the female rarely if ever essays flight. Sisters of this insect, when artificially dealated, founded colonies under laboratory conditions in the manner to be described below.

The situation in *Myrmecia regularis* appears to be even more interesting. It was fortunately possible to thoroughly examine some ten large nests of this species in the magnificent eucalypt forests just south of Manjimup, West Australia—a location almost identical with that where many of Wheeler's observations were carried forward—just at the period when the mature sexual forms were preparing to emerge from the nest. Numerous males were seen in many of these nests. In many of them callow females were also observed, but in a curious and anomalous condition. The nests were all located under large and rather moist eucalyptus logs, and in many of them superficial galleries were found to be crowded with *decidedly callow, yet dealate,* females. Often ten or fifteen individuals were seen in a single group, which fled precipitately into the lower galleries when pursued. Only one winged young female was found, and this was an exceedingly callow individual, the short wings of which barely reached the third gastric segment. On

the same day, a fully pigmented, solitary, isolated, colony-founding female of the same species was taken nearby under conditions exactly similar to those described by Wheeler, and a little further on an incipient colony, consisting of a queen and six young workers, was disclosed.

It seems likely that the larger colonies of *M. regularis* are normally pleometrotic, like those of *P. pilosula*, although it was not possible to prove this. It seems improbable in the extreme, however, that the crowds of dealate callow females found in the surface galleries of these nests were brood-queens which had returned to their parent formicaries after flight, for if this were true, emergence from the nest would have taken place while the queens were in a very callow and relatively helpless state. It seems much more probable to the authors, from these observations, that the young queens of *M. regularis* normally drop the wings while still callow and while still in the parental nest, thereafter, when mature, emerging wingless into the open to be fecundated on the ground or on bushes or trees and later to isolate themselves and begin new colonies in the fashion peculiar to these primitive ants. Such an assumption was later reinforced by the fact that six of these dealate callows, taken from four colonies, all isolated themselves after a period of wandering and excavated typical cells under artificial conditions, from which they foraged at intervals in normal fashion.

If this interpretation of the behavior of the young females of *M. regularis* be correct, it forms a natural transition to the situation in *Myrmecia tarsata*. Here the functional females are ergatoid in form, the thorax being workerlike, and the differences between the sexual females and the largest workers being but slight. The "nuptial flight" of this species was observed at length near Pymble, N. S. W., where the species is abundant, in March of 1948. Great numbers of winged males and wingless females were produced from numerous relatively large formicaries. The males promptly took flight and disappeared. The females wandered away slowly. Judging from these observations, and from confirmatory statements of Father John McAreavey (*in litteris*), these young females must wander for some time in the open, possibly for a period of several weeks, during which they are found and fertilized by the active males. Subsequently they form bivouacs and proceed to the establishment of the colony in the typical general pattern of the Myrmecii, as has been shown by McAreavey and as was confirmed in these studies with a number of young females taken wandering in the open.

The pattern of the nuptial flight among the Myrmecii is thus of a markedly primitive and generalized character, and is reminiscent of the mating procedure of many of the lower vespoids, solitary as well as social. Within this single tribe, there are elements corresponding to many diverging patterns among the more specialized ants, suggesting, though never quite attaining, the concerted, well-defined flights in such genera as *Atta* or *Lasius* on the one hand, in which the queens actively participate, and foreshadowing, but, again, never actually reaching the opposite extreme among the Dorylinae, on the other, in which the males, as Schneirla has shown (1948), apparently join the columns of the young females to fecundate them.

The method of colony foundation among the Myrmecii is likewise

extraordinarily primitive and generalized, and may well represent the ancestral mode among ants as a whole.   It was first formulated extensively by Wheeler (1933) as a conjecture based upon a number of indirect observations.   Clark (1925) had already recorded that the young females of a number of species of *Myrmecia* isolate themselves in single cells, sometimes alone and sometimes in company with others, and that young brood is present in such chambers, which is fed on insect prey supplied by the queen.   Wheeler noticed further that such chambers were usually constructed with a superficial cell at the surface of the soil, which, while placed directly under a stone or log or other natural cover, was invariably located near the edge of the overlying object, so that it would be very easy for the imprisoned insect to remove a portion of the wall of the chamber and leave it periodically to forage.   He found a few such cells containing active brood but no fertile female, and concluded that, at the moment of intrusion, the parent was absent. Confirmatory to this conjecture, he also succeeded in finding dealate females foraging in the open, as Clark had done before him.[2]   These observations, together with that of a nest of *M. regularis* in which the soil at the margin of the brood-chamber had been freshly disturbed, led him to conclude with Clark that the young females of *Myrmecia*, following the nuptial flight, typically excavate and occupy a large brood chamber, which, though sealed to the outside, is so constructed that it can be opened, permitting the occupant to emerge to forage.   He further concluded that this foraging is done quite regularly, both before and after the brood has appeared, and that subsequent to the hatching of the larvae, the female provides them continuously with insect food in addition to foraging for nectar to sustain herself.   Wheeler was not able to confirm his conjecture by studies in the artificial nest. Clark (1934a) has done so, but has never published detailed accounts of the procedure.   A re-investigation of the details of this significant process in the artificial nest therefore seemed worth while.

It has been a particular pleasure to be able to confirm the statements of Clark and of Wheeler by direct observation upon a number of species in the artificial nest, and to fill in the details of the entire process.   Young females of *Promyrmecia piliventris, Myrmecia forficata, M. vindex,* and *M. regularis* observed under artificial conditions all constructed cells under stones, bits of logs, or darkened glass plates which closely resembled the natural ones described by Clark and Wheeler. The cells were carefully finished and closed to the outside when the owner retired into them.   Wherever possible, such cells were provided with an upper chamber, directly at the surface and excavated near the edge of some covering support, and a lower one, two or three inches underground and connected by one or more short, wide, galleries.   From the time that the cells were finished and closed (a process which for its rough completion required three or four days of more or less continuous work on the part of the female) they were opened regularly and the young queen issued to feed on the honey provided.   Most of these feeding trips were nocturnal, and in some species, notably *M. regularis,* they took place with great regularity at about six o'clock each evening,

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[2]Both of these observations were personally confirmed in the course of the present work: the first with *Myrmecia forficata* on Mt. Kosciusko, the second with *M. nigrocincta* at Pymble, N. S. W.

the female continuing to wander through much of the night but return-
ing and closing the cell before morning. Within a few weeks the
spherical eggs appeared, loosely scattered on the floor of the chamber,
and were assiduously attended. Until they hatched, little attention
was paid to insect food by the nurse, although it was occasionally licked.
As soon as young larvae appeared, however, fragments of mealworms
and other insect prey were regularly carried into the chamber on these
nightly foraging expeditions and provided to the young. The larvae
were kept in a compact packet and were licked avidly for exudates
almost from the time of hatching, as earlier indicated. They developed
relatively rapidly, and at maturity were banked with earth by the
queen in typical fashion and the cocoons were exhumed and cleaned as
soon as they were completed. At this time the female ceased to bring
insect prey into the nest chamber, but continued to feed on it to a
certain extent outside. The queen continued to forage until, and
after, the young workers appeared.

A typical history of the foundation of a colony by a fertile female
of *Myrmecia forficata* is shown below:

> 1947.
>
> August 15.   Young female established in artificial nest. Exca-
>   vated typical chamber shortly thereafter and
>   retired into it, emerging regularly at night to
>   forage.
> September 3. Eight eggs found in nest.
> September 29. Group of small, newly-hatched larvae found feeding
>   on mealworm fragment carried into nest by female.
> October 4.   Four larvae, apparently about one-quarter grown,
>   observed in nest.
> October 28.   One small but perfect cocoon and two apparently
>   half-grown larvae observed.
> October 29.   One cocoon, one larva, and one larva banked with
>   earth and in the process of spinning.
> October 31.   Three cocoons in nest.
> November 3.   Three cocoons, closely guarded by female.
> November 8.   Three cocoons, which have been removed to the
>   driest portion of the chamber excavated by the
>   queen, and are closely guarded.
> December 12. First cocoon eclosed small but perfect young worker.
> December 16. Second cocoon eclosed small but perfect young
>   worker. The third cocoon failed of eclosure.

This whole primitive and generalized picture of the initiation of the
social structure among the Myrmecii is of the highest significance for
our understanding of the basis of formicid society in general, and is
deserving of more quantitative study than it has so far received. It
will be important to know, for instance, whether the degeneration of
wing-musculature in the female with the consequent increment of nutri-
tive material, which is initiated at dealation among many if not most
of the higher forms, is duplicated among the Myrmecii. Studies of
the histology of the wing-musculature in such queens among the
Myrmecii and the Amblyoponii are in progress at present. Preliminary
results indicate that quite probably no such coordinated breakdown
takes place in these primitive forms, and that the wing muscles therefore
may not constitute any sort of food reserve, as they do among
higher ants.

If this situation should be more completely confirmed, it will be interesting to notice that it is precisely among those forms in which wing-muscle degeneration does not occur and where foraging of the colony-founding queen is the rule that wingless worker-like females with reduced thoraces occur so frequently, a conclusion which may suggest that the primary evolutionary significance of bulky wing-muscles in the higher ants is as a tissue reservoir, and that the special-ized flights which they make possible may be of secondary significance in evolutionary terms, representing a desirable, but by no means an essential, means of securing the dispersion and the genetic heterozygos-ity evidently important to the survival of the species. This question is being investigated much further.

Among those higher ants in which the young females form their colonies in typical solitary and claustral fashion, the maturing of the first brood of workers coincides fairly closely with a significant change in the behavior of the queen. The general nest-functions which she has hitherto served are almost entirely abandoned, her activities are restricted very largely to egg-laying, and she becomes wholly dependent upon the workers for food. This change does not occur, or occurs very gradually, in *Myrmecia*. When the first brood of workers is mature, the fertile female continues to forage with them outside of the nest for some time, at least in *Myrmecia gulosa*, *M. forficata*, and *M. reg-ularis*, where such behavior has been often observed. This pattern is in fact essential for the queen, since the workers are unable to distribute ingluvial food to her. Throughout the rearing of the second and more numerous group of larvae, therefore, the queen probably continues to be the most significant single factor in all phases of colonial activity.

The subsequent picture is much less clear, and presents a fascinating problem. Does the queen continue to emerge from the nest to forage throughout the life of the colony? In the artificial nest, mature, and indeed very old queens of *Promyrmecia pilosula* and *P. piliventris* in relatively populous colonies regularly continued to emerge with the workers to feed at the honey dishes. When removed from populous colonies, or when deprived of most of their worker personnel, old females of *Myrmecia tarsata*, *M. forficata*, and *M. vindex* have in the artificial nest reverted almost immediately to the behavior pattern of young colony-founding females, emerging regularly to forage and assiduously tending larvae entrusted to them. In several instances these females were taken from very large colonies and since, in these species, the colonies regularly contain only the founding females, they must have been several years old at the time of capture. Such a ready reversion to independent existence, even at an advanced age, emphasizes once again how lowly specialized the perfect female of *Myrmecia* and *Pro-myrmecia* is to a social structure.

It is questionable whether this regular emergence of the old female to forage which has been repeatedly observed in the artificial nest occurs in the wild, and it has not yet been possible to establish this through field observations. Fertile brood females in large colonies of all the species examined were always found—when they could be taken at all—in the lowest and most remote reaches of the nest, and were in general full-fed and somewhat physogastric, suggesting that some

source of nourishment was available within the formicary. It is very conceivable that the fertile female, to an even greater extent than the smallest workers, may subsist on larval exudates and on insect food brought within the nest during the height of the brood-rearing season. What the behavior of such females may be at other times, however, remains a puzzle to be elucidated.

It follows from what has been said that the social position of the queen of *Myrmecia* or *Promyrmecia* within the colony is little different from that of a worker. As among so many of the lower Ponerinae, no special attention is paid her, and except for the fact that she is somewhat more sedentary, somewhat more highly fertile, and somewhat less aggressive than the workers, there is little behaviorally to differentiate her from the rest of the colony personnel.

FERTILITY OF WORKERS, AND DEVELOPMENT OF WORKER-LAID BROOD

In all the species of *Myrmecia* and *Promyrmecia* observed in the artificial nest, the workers have been highly fertile and have contributed markedly to the brood of the colony. Worker-laid eggs have been reared to maturity in colonies of *Promyrmecia piliventris* and *Myrmecia nigrocincta* in which fertile females were not present. In every case, such broods consisted entirely of males, thus agreeing with the usual situation reported among the higher ants, although this does not appear to be invariable (Haskins and Enzmann, 1945).[3]

SENSES

The Myrmecii are very unusual among ants in that vision is predominantly relied upon as a factor in orientation outside the nest during daylight hours. The large, convex compound eyes are exceedingly sensitive in detecting movement, and every action of the insects in foraging is indicative of the reliance placed in them. Among many species of *Myrmecia*, the antenna are never brought into play during daylight foraging except in actual exploration for prey. As previously observed, no evidence of the trail-following procedures so characteristic of higher ants could be found during daylight in the two-day series of observations of *Myrmecia gulosa* recorded. After dark, however, and presumably underground, the situation is very different. Observation of some ten colonies of *Myrmecia gulosa* were made during the night of January 13, 1947 (when the daylight observations recorded had just been completed). The night was very dark, and observations were made with the aid of a dim taper. They disclosed undiminished activity on the nest crater, but of a very different kind from that of the daylight hours. There was no foraging, and activity was restricted to excavation. Streams of ants were passing to and fro on the crater, building up its rim with earth granules. On these trips, which were limited in scope to two or three feet, the antennae were brought into play constantly, and there was no evidence of any reliance upon vision. The ants were wholly insensitive to the light of the taper even when brought close to them, and displayed no reaction whatever to gross movements in their immediate vicinity. No contrast could have been

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[3]Brood brought to the late pupal stage by two artificially dealated infertile females of *Promyrmecia piliventris* was likewise male.

greater to their highly observant, sensitive, and aggressive attitude during the daylight hours.

Two series of experiments were made in an attempt to determine the ability of the Myrmecii to distinguish colors, and the significance of color vision for them. Both were negative. In the first, colored plastic cups were used in the experiments described with *M. gulosa* and the colors were interchanged about the nest at intervals. No indication was ever found that a marked worker, having become habituated to visiting a cup of a particular color, tended to follow that color when it was interchanged with another. Instead, position seemed to be the governing factor, and any new color that was substituted was accepted readily. If both colors were moved to new positions, the individual wandered at random until one or the other was discovered, and thereafter returned to that spot. In these experiments at least, therefore, color appeared to have no significance.

In the second series, several pairs of Wratten filters, so chosen as to transmit equal intensities of light in widely separated portions of the spectrum, were placed over glass Lubbock nests containing colonies of *Myrmecia nigrocincta* and *M. tarsata*. These nests, normally kept in darkness, were then strongly illuminated with white light. Brood was carried under the filter squares, as was expected, but an interchanging of the squares was not followed by any shift in the quantities of brood under each, nor in any tendency of one ant to follow a particular square. This behavior is in rather marked contrast to the normal behavior of many higher ants which have been tested under similar conditions, in which the filters transmitting longer wave lengths are almost invariably preferred. It is also unlike that of *Euponera gilva* in experiments earlier reported (Haskins, 1931), in which individuals tended to follow a given filter. It has so far proved impossible to determine whether there are marked differences in sensitivity of light perception in different portions of the spectrum in *Myrmecia* and *Promyrmecia*.

Experiments to determine the existence of a sense of hearing in *Myrmecia* and *Promyrmecia* proved almost as difficult and unsatisfactory as those connected with vision. The primary difficulty was the detection of a visible reaction to sound, since the insects, although very alert and reactive, are inclined when startled to "freeze" to immobility, and thereafter to exhibit no further responses to stimuli. It was, however, possible to demonstrate reactivity to musical notes covering the chromatic scale (Table I), although such reactions, while positive, were sporadic. Lubbock nests containing colonies of various species were mounted on multiple layers of turkish toweling, resting in turn on an upholstered support, to eliminate mechanically transmitted vibration in so far as possible, and notes were sounded with a pitch pipe some three inches above the covering glass of the Lubbock nest. The nests were so arranged that the ants were fully protected from air currents. Each note was sounded three times. Five trials of the chromatic series were made for each nest, each trial being separated by a resting period of from fifteen to thirty minutes, each series being recorded separately. Each series for the same nest was begun alternately at the high and the low end of the scale. The method used was that described by Haskins and Enzmann (1938) in tests with various other ants. The

TABLE I

REACTION OF VARIOUS SPECIES OF MYRMECIA AND PROMYRMECIA TO
NOTES OF THE CHROMATIC SCALE

SPECIES TESTED	F		F#		G		G#		A		A#		B		C		C#		D		D#		E		F	
	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−
Myrmecia forficata (1)	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5
Myrmecia forficata (2)	4	1	2	3	2	3	1	4	0	5	0	5	0	5	2	3	1	4	1	4	3	2	2	3	3	2
Myrmecia vindex (1)	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	3	2
Myrmecia vindex (2)	1	4	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	1	4	0	5	1	4
Myrmecia tarsata (1)	1	4	1	4	2	3	0	5	1	4	1	4	0	5	1	4	1	4	2	3	4	1	3	2	1	4
Myrmecia tarsata (2)	3	2	0	5	1	4	1	4	3	2	0	5	3	2	1	4	1	4	4	1	4	1	3	2	4	1
Myrmecia nigrocincta	1	4	2	3	3	2	3	2	1	4	2	3	2	3	1	4	1	4	1	4	2	3	4	1	3	2
Myrmecia swalei	1	4	3	2	1	4	2	3	1	4	3	2	0	5	4	1	5	0	4	1	4	1	5	0	4	1
Promyrmecia piliventris (1)	2	3	2	3	0	5	0	5	0	5	0	5	0	5	0	5	0	5	1	4	1	4	2	3	4	1
Promyrmecia piliventris (2)	2	3	3	2	3	2	1	4	1	4	1	4	3	2	3	2	3	2	4	1	3	2	4	1	4	1
Promyrmecia piliventris (3)	1	4	2	3	2	3	2	3	1	4	1	4	2	3	3	2	3	2	2	3	3	2	2	3	2	3
Promyrmecia piliventris (4)	2	3	1	4	1	4	1	4	0	5	0	5	1	4	0	5	1	4	0	5	0	5	3	2	2	3
Promyrmecia pilosula (1)	2	3	3	2	2	3	2	3	2	3	0	5	1	4	4	1	1	4	2	3	4	1	1	2	2	3
Promyrmecia pilosula (2)	2	3	3	2	1	4	1	4	0	5	0	5	0	5	1	4	0	5	3	3	2	3	1	4	2	2
Promyrmecia pilosula (3)	1	4	2	3	1	4	1	4	2	3	1	4	4	1	3	1	3	2	4	1	3	2	3	2	3	2

+ = positive observations.
− = negative.

results were as shown. It will be seen that some positive reactions were secured for most of the species over the entire chromatic scale.

The olfactory sense, though less constantly used than among most of the higher ants, is nevertheless acute, and is evidently employed extensively in the location of food and within the nest. Its keenness is well attested by the ease with which alien ants, even of the same species, are detected in the colony, as already described. It is also well shown by the violence of reaction to various foreign odors about the nest region, even when these are in rather extreme dilution. As in the higher ants, there seems much evidence that the olfactory sense is closely associated with the tactile sensory areas of the antennae. It seems probable that the two classes of sensations are very considerably fused.

Taste is also highly developed, as among the higher ants. The Myrmecii are discriminating in their choice of nectarivorous substances. Small quantities of strong-tasting foreign matter included in solution with honey will result in its immediate rejection.

SIZE OF COLONIES

The loose structure and the low degree of co-ordination so characteristic of the Myrmecii would lead the observer to expect that such colonies would, on the whole, be quite limited in numbers. It has been generally supposed that the colonies of *Myrmecia* and *Promyrmecia* rarely exceed 200 individuals. This is true of some forms, and colonies of such size are not uncommon in most. There are, however, certain striking exceptions, notably in such species as *Myrmecia regularis*, *M. tarsata*, *M. gulosa*, *Promyrmecia piliventris*, and *P. pilosula*. To determine this question more accurately, a number of colonies of several species were extracted as nearly completely as possible and the members counted. These counts were made at approximately the height of the season of growth, after the greater portion of the worker and sexual brood had been eclosed, and just before or just after the sexual forms had left the parental nests. The results of these counts were as shown in Table II.

Attention may particularly be drawn to the second colonies of *Promyrmecia pilosula* and of *Myrmecia gulosa* listed above, for which the counts exceeded 1000 and 2000 individuals respectively. Both of these colonies were in situations which were difficult to excavate, and, despite some eight hours of work with each of them, it was never possible to penetrate to the center nor to discover the brood queens. It may be conservatively estimated that not more than 70–90% of the individuals in these colonies were counted. These colonies, moreover, were not especially remarkable for their size.

It is interesting to reflect, therefore, that several species of *Myrmecia* and *Promyrmecia* probably are able to maintain larger stable communities than a very considerable proportion of the higher ants, despite the generalization of the workers, the relatively low fertility of the queens, and, above all, the absence of the habit of distribution of inglulvial food among the workers. This last bond of colonial solidarity seems so basic among the higher ants that it is most surprising to see it successfully substituted in the Myrmecii by other influences. Chief among these, undoubtedly, are the strong individual fixations of the

workers for the nest locality, and the focal stimuli provided by a plentiful supply of brood during the season of maximum foraging. The importance of the brood as a social stimulus is well illustrated by the extreme precision of co-ordination between the foraging habits of the workers and the state of development of the brood already mentioned. A further stimulus, of a negative kind, may be offered by the extreme

TABLE II

COUNTED NUMBERS IN COLONIES OF MYRMECIA AND PROMYRMECIA

Species	Location	Date of Count	No. of Individuals
Myrmecia vindex	Perth, W. A.	Mar. 15, 1948	1 mature female 12 winged females 94 workers 12 pupae Total: 119
Myrmecia vindex*	Bellevue, W. A.	Mar. 3, 1948	4 winged females 268 workers 10 pupae 10 larvae Total: 292
Myrmecia gulosa*	National Park, N. S. W.	Mar. 22, 1948	188 workers 23 cocoons Total: 211
Myrmecia gulosa*	Sutherland, N. S. W.	Mar. 24, 1948	1586 workers 424 cocoons 104 larvae Total: 2114
Promyrmecia pilosula	Ferntree Gully, Victoria	Feb. 26, 1948	4 mature females 549 workers 178 pupae Total: 731
Promyrmecia pilosula*	Ferntree Gully, Victoria	Feb. 26, 1948	55 males 807 workers 206 pupae Total: 1068

*In these cases, it was impossible, in the time available, to extract the complete colony. It may be guessed that the numbers given represent 70–90% of the entire personnel.

hostility of alien colonies to workers that may attempt to seek refuge in them. It may well also be that stability of colonial organization is promoted by an unusual natural life span of both fertile female and worker. This question is under present investigation.

PARASITES AND COLONIAL SYMBIONTS

The simplicity of colonial organization in the Myrmecii, their vigilance, and their implacable hostility to such alien intruders as they

detect within their formicaries result in a paucity of parasites or colonial symbionts unusual among such large ants harboring such an abundance of potential food material within their formicaries. The most conspicuous true parasites commonly found in the nests are undoubtedly the chalcidids of the genus *Eucharis*, several species of which are frequently associated with various species of *Myrmecia* and *Promyrmecia*. They attack the larvae exclusively. Wheeler (1933) has shown that adults of *Myrmecia* are sometimes infested with the parasitic nematode *Mermis*. No such individuals were encountered in the present studies.

Few smaller ants are to be found in the immediate vicinity of the nests of *Myrmecia* and *Promyrmecia*, for the vigilance of the large ponerines makes invasion or theft by the alien species difficult. An exception is provided, however, by the specialized ponerine *Brachyponera lutea*, one of the commonest and most ubiquitous ants of Australia, unique among ponerines in the remarkable differentiation, both in size and form, between its queens and workers. This species, which tends to nest close to the formicaries of many ants and colonies of termites, is quite capable of securing the eggs and young larvae of *Myrmecia* without being detected, and is not infrequently found nesting in or near the craters of such larger species as *Myrmecia gulosa*.

Perhaps the most interesting relation with alien species to be found among the Myrmecii, however, is that existing between *Myrmecia regularis* and the small toad *Pseudophryne nichollsi* Harrison, a relation first reported by Barbour and Loveridge (1929) at Manjimup, in southwestern West Australia. The toads were found again in this locality by Wheeler and Schevill (Wheeler, 1933). It was possible in the course of the present work to fully confirm the findings of Barbour and Loveridge at Manjimup, and also to study the toads in the artificial nest in association with their normal host, and with other species of *Myrmecia* and *Promyrmecia*.

The toads, small and rather fragile, rarely exceed 25 mm. in length, are of a plain dark-brown coloration, and normally live subterranean lives concealed under heavy rocks or logs in the normally rather damp soil of the region. Here they crawl about slowly in search of insect prey. They have never been seen to hop, even when opportunity was provided to do so. They are unusual among the anurans in that the eggs, laid in the soil, hatch directly into small perfect toads, the tadpole stage having been completed in the ovum.

Numerous specimens of *Pseudophryne* were seen and captured at Manjumup during March, 1948. All of them were located in the central galleries and chambers of large and pugnacious colonies of *M. regularis*, which swarmed over them when the nests were disturbed, but which, even when most excited, paid no attention to them whatever. Captured specimens of *Pseudophryne* were introduced into colonies of *M. regularis* housed in Lubbock nests, where they lived successfully for several months. Neither ants nor toads paid the slightest attention to one another, notwithstanding the fact that the toads wandered throughout the ants' nests, and examined the brood piles—a procedure which would not have been tolerated from any other intruder. The toads were never seen to attack adult ants or to menace the brood. Instead, they fed by "lapping" podurans and similar small insects

which collected in the vicinity of the rather massive underground kitchen middens maintained by the *Myrmecias*. The toads were always most abundant in the vicinity of these piles of discarded insect fragments, and it seems probable that much if not all of their normal subsistence was obtained in this manner.

An individual *Pseudophryne* was transferred from its colony of *M. regularis* to a colony of *P. pilosula*, and the reactions observed. Interestingly, they were not immediately overtly hostile on the part of the ants, but it was evident that the presence of the toad was definitely detected by *Promyrmecia* and it was eventually attacked.

The relationship with *M. regularis* is evidently specific, but it is almost certainly facultative. Many colonies of *M. regularis* were found without the toads, and, although the toads were not found separate from the ants in the course of these studies, made in March, Wheeler and Schevill, collecting in November, found only specimens that were living apart from the ants. It seems probable that the toads are attracted into the ant colonies later in the season, when the refuse collected in the kitchen middens has become more abundant, and when these have therefore become focal points for the minute insects on which it is to be presumed that *Pseudophryne* normally subsists.

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PHYLLODY OF CHRYSANTHEMUM AND THE ERIOPHYID MITE, PARAPHYTOPTUS CHRYSANTHEMI KEIFER[1]

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On October 19, 1948, a florist of Woodinville, Washington, brought some chrysanthemum plants that were dwarfed and stunted to the Western Washington Experiment Station. The older leaves on these plants were distinctly reddish in color and no flowers had formed on some of them, while others bore a few that were severely deformed. Careful examination of the plants disclosed that the flower parts had

FIGURE 1   FIGURE 2

FIG. 1. Phyllody of the chrysanthemum involving altered and stunted growth. Note phylloid flowers in axils of leaves.

FIG. 2. Phyllody of the chrysanthemum. Leaves have been removed to show shortened internodes.

become vegetative and that their formation had been altered early in their development. Also, the stems were shortened between the

internodes (fig. 2), and there was an increase and a clustering of the stems resulting in a witches'-broom effect (fig. 1). Numerous eriophyid mites, *Paraphytoptus chrysanthemi* Keifer (fig. 3), were found in these deformed "buds." The presence of these mites and the fact that related species of mites are known to cause malformations of various kinds in other plants suggests that they are the probable cause of the "disease" of the Woodinville chrysanthemums.

Heald (1) defines phyllody as follows: "The term 'phyllody' is applied to the change of floral organs into leafy structures. While phyllody is frequently caused by the presence of a parasite, other disturbances may produce similar effects." More recently, Dana (2) defined phyllody as "A vegetative change in the flower by which some or all of the parts of the flower become more or less leaflike." It was interesting to note that some of the phylloid flowers of the chrysanthemums bore traces of the coloring that would normally have been depos-
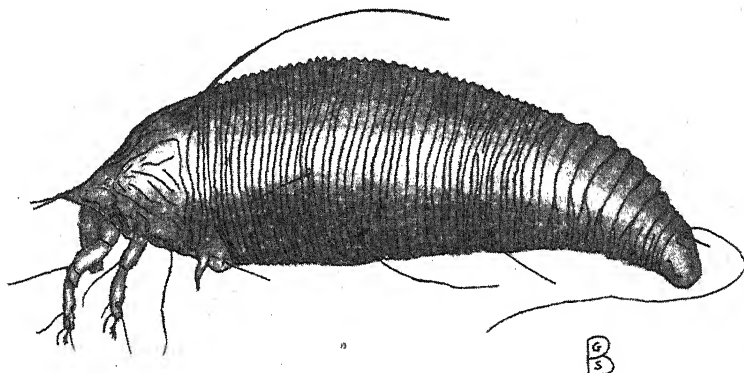
FIG. 3.   The eriophyid mite, *Paraphytoptus chrysanthemi* Keifer.

ited in the flowers. It seems that the chrysanthemums in question fulfill all the requirements of the definitions, and that we are concerned with a case of true phyllody.

The family Eriophyidae contains rust mites, blister mites, erinose mites, gall mites, bud mites, and the blackberry mite, *Eriophyes essigi* Hassan, cause of the red berry disease of the blackberry. Smith and Stafford (3) found that the bud mite of grapes, *Eriophyes vitis* (Pgst.), caused a pronounced shortening of the internodes of new growth in the spring, flattened canes, and killed the terminal buds. The killing of the terminal buds resulted in the development of a witches'-broom growth of new shoots and in the production of zigzagged shoots. Many years ago, Kerner and Oliver (4) described a fasciation of the ash, *Fraxinus excelsior* L. and *F. ornus* L., which was caused by a mite of the genus *Phytoptus* (*Eriophyes*). The similarities between the ways in which the bud mite affected the development of the grapes and *Para-*

phytoptus chrysanthemi altered the development of the chrysanthemums are apparent.

Keifer (5) originally found *Paraphytoptus chrysanthemi* around the leaf-axil buds and in the terminal flowers of the chrysanthemums from which he obtained the type sepcimens. He commented, however, that no damage was noted. It is possible, of course, for mites belonging to this group to be present on the plants and produce no evident damage. However, in the instance being reported, damage was great and accounted for practically 100 percent loss in flowers. The three varieties of chrysanthemums observed by the writers as being affected by the presence of these mites were *Wendy*, an early English bronze, *Red Rover* and *Lavender Lady*. All varieties were grown out-of-doors for cut flowers.

In discussing the situation with the florist, particularly with reference to the origin of the infestation, it was suggested that it may have originated with a shipment of chrysanthemum varieties that were obtained from Japan soon after the close of the recent war. First indications of the condition appeared in 1947, but were not pronounced and were not given serious consideration.

A review of the literature indicates that we are apparently reporting the first probable relationship between phyllody and eriophyid mites.

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INSECTOS DO BRASIL, VOL. VI, LEPIDÓPTEROS, PART 2, by A. da Costa Lima. 420 pages, 331 text figures. Escola Nacional de Agronomia, Série Didática No. 8. 1950.

This volume, which concludes the Lepidoptera (see review of Part 1, Ann. Ent. Soc. Amer. 39:241, 1946), covers the Macrofrenatae, or, more specifically, the superfamilies Pyralidoïdea, Drepanoidea, Sphingoidea, Geometroidea, Uranioidea, Notontoidea, Noctuoidea, Mimallonoidea, Saturnioidea, Bombycoidea, Lasiocampoidea, Hesperioidea, Papilionoidea, and Nymphaloidea. The plan and quality of the work is comparable to that of the preceding part.

As would be expected, considerable space is devoted to the economically more important insects; for example, sixteen pages are given to the sugar cane borer, *Diatraea saccharalis* (F.). Some pests common to North American and Brazil, for example, *Galleria mellonella* (L.), *Plodia interpunctella* (Hübner), *Heliothis obsoleta* (F.), and *Alabama argillacea* (Hübner), are treated in like fashion, and the inclusion of some non-Brazilian pests, such as the European corn borer, is something of a surprise. Among the more interesting material included is a discussion of moths ectoparasitic in the fur of living sloths (p. 25). Also deserving of mention are the descriptions of the migratory habits of *Urania* (pp. 146–7) and of the aquatic habits of the larvae of the arctiid *Pallustra* (pp. 227–9).— M. T. J.

ENTOMOGENOUS FUNGI OF THE GENUS METARRHIZIUM ON WIREWORMS IN THE PACIFIC NORTHWEST

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During 1932 to 1942 facilities for the culture and study of entomogenous fungi were available at the Forest Grove, Ore., station of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture. The writer devoted some time to this work, especially in the winter months, and the following information on two species of *Metarrhizium* was acquired at that time.

Metarrhizium brunneum Petch

This species was described by Petch in 1935 (5) from material "on a homopterous insect (Cicadellidae), collected at Laguna, Philippine Islands, December, 1931." On June 25, 1933, T. R. Chamberlin discovered a fungous outcropping on four larvae of *Limonius* sp. being reared in their native soil in tin salve boxes at Forest Grove. Mr. Chamberlin had collected these wireworms in a field on Gales Creek bottom land about 5 miles northwest of Forest Grove. The soil in this area is classed as Chehalis Silt Loam (Watson *et al*, 9). By July 7 all four wireworms had died of a fungous disease. A pure growth of fungus had developed in all. A white cottony mycelium appeared first, some of which spread out in interwoven, Isaria-like strands for as much as 20 mm. beyond the body of the insect. On the ends of these strands, palisade-like layers of spores were formed. The color of this sporiferous layer was light drab (Ridgway, 6), blending with the color of the soil. The spores clung together both laterally and linearly and the spore masses broke up, when touched, into sharp angled, columnar aggregations resembling talus. The normal cylindrical spores were measured, with an ocular micrometer, as 7.4 to 9.2 microns by 2.5 to 2.8 microns. Some smaller spores measured 5.5 by 1.8 microns. These measurements come within the limits of *Metarrhizium anisopliae* (Metsch.), but the color was quite different, and the writer concluded that the fungus was an undescribed species of *Metarrhizium*.

Transfers were easily made direct from the wireworms to potato, on which the fungus overgrew any secondary infection by bacteria or fungi. It was later grown in pure culture on several media, including meat, fish, and custard. On potato the color of the sporiferous layer was somewhat darker—wood brown or drab (Ridgway, 6)—than on the wireworms, but the spore measurements remained constant. In cultures the mycelial layer was white, with a narrow, cinnamon-brown

Ridgway, 6) streak next to the substratum, closely woven, tough and mat-like. The drab sporiferous layer on flat cultures in Erlenmeyer flasks had a slightly roughened or pebbled surface, not as smooth as that of *M. anisopliae*. This pebbled surface appeared to be caused by differences in the length of the branches of the sporophores at the time of spore formation. In *M. anisopliae*, all branches appear to reach the same level, like a corymb, before producing spores. Cultures of *M. brunneum* sometimes formed round-headed bodies after the brown sporiferous layer had been formed, when outcrops of the snowy-white mycelial layer pushed through. Some of these puffball-like bodies never seemed to develop spores on their periphery, and a culture taken from this extruded mycelium made a sparse growth and remained sterile. It was noted that, in culture, *M. brunneum* produced a longer mycelial growth and began spore production about 5 days later than did *M. anisopliae*.

Dr. Vera K. Charles of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, suggested, in a letter dated April 2, 1936, that this fungus might be "*M. brunneum* of Petch, but your spores exceed the measurements given for this species." On September 27, 1943, cultures of this fungus were sent to the Northern Regional Research Laboratory, Peoria, Illinois, where the fungus was given the designation "*Metarrhizium* sp. NRRL 1944, Rockwood No. 1." Dr. W. Lawrence White, of the Farlow Reference Library and Herbarium of Cryptogamic Botany, Harvard University, has since written (letter of June 10, 1948) that he had worked some with this fungus, which he had obtained from Dr. Raper of the Northern Regional Research Laboratory. He stated that Dr. Petch had confirmed his identification of the fungus as *M. brunneum* Petch. In 1940 several large cultures of this fungus (in milk bottles) were sent to F. H. Shirck, of the Bureau of Entomology and Plant Quarantine, at Parma, Idaho. On June 18, 1940, spores from these cultures were mixed with soil and placed with several thousand wireworms in moist soil. The wireworms were later released in six locations near Parma.[2]

Metarrhizium anisopliae (Metsch.) Sorokin

This entomogenous fungus has been known since 1879 and has been recorded on various insects and under several names. Among these names are *Entomophthora anisopliae* Metsch. (Metschnikoff, 1879), *Oospora destructor* Delacroix (Delacroix, 2), and *Penicillium anisopliae* Vuillemin (Vuillemin, 8). Petch (4) has reviewed the genus and discussed variations in the size of the spores.

The writer was familiar with this fungus, as he saw many specimens from several localities, mostly on elaterid larvae, but also on tenebrionid larvae, on scarabaeid larvae, pupae, and adults, on noctuid larvae and pupae, and on *Sphenophorus* larvae. In 1914 he infected adults of *Hypera postica* (Gyll.) with this fungus in the laboratory and found it less virulent to weevils than *Beauveria globulifera* Speg. (Rockwood, 7). At that time he observed fungous bodies in infected but still living

[2]Personal correspondence with F. H. Shirck, February 16, 1942.

weevils. Some of these bodies, in silkworms, have been illustrated by Glaser (3).

In 1925 Barss and Stearns (1) recorded this species on the European earwig, *Forficula auricularia* L., and other insects in Oregon. The writer saw this fungus in the Pacific Northwest on an *Omus* larva collected near Forest Grove by Sadie E. Keen on August 4, 1922 (spores 4.6 to 8.3 microns by 1.9 to 2.9 microns); on *Euxoa atomaris* Smith larvae collected on March 26, 1926 near Forest Grove (spores typical); on *Porosagrotis vetusta* (Walker) larvae, and parasite *Amblyteles*, collected near The Dalles, Oregon, on April 25, 1928 (spores 3.7 to 6.6 microns by 2.8 microns); on *Agrotis ypsilon* (Rott.) larvae collected near Gaston, Oregon, on July 31, 1938 (spores 6 to 8 microns by 3 microns); and on the carabid larva, *Amara obesa* Say, from Klamath Marsh in northern Klamath County, Oregon, on May 23, 1936 (spores typical). The fungus was obtained in pure culture from this last specimen and is hereafter called the Amara strain. The color of the sporiferous layer of this strain was between deep grayish olive and Andover green (Ridgway, 6).

In 1937 a strain of *M. anisopliae* on a wireworm *Limonius californicus* (Mann.), collected near Parma, Idaho, by Mr. Shirck, was brought into pure culture with considerable difficulty because the natural material was contaminated by bacteria and saprophytic fungi. This strain is hereafter referred to as the Idaho strain. The sporiferous layer of this fungus has a somewhat paler green color—Lincoln green (Ridgway, 6)—than that of the Amara strain, although the spores measure the same, 7 microns by 2.5 to 2.75 microns. Cultures of this strain were also sent to the Northern Regional Research Laboratory on September 27, 1943. On wireworms this fungus showed a short mycelial growth externally, forming cushion-like outcroppings at the sutures.

INFECTION EXPERIMENTS

The writer was supplied by Mr. Shirck with large stocks of wireworms for experimental purposes during 1936 to 1941. Naturally infected wireworms, a very small percentage in these stocks, were eliminated by holding them for a month or more in the original containers and culling dead worms before infection experiments were conducted in tin salve boxes containing sterilized Gales Creek sand. The most disturbing factor in these experiments was not prior infection with fungus, but the presence of mites on the wireworms. In one year, when the wireworms had been kept overlong at room temperatures, mites caused a large loss of wireworms. Infection by the fungi was brought about in two ways, by shaking the wireworms in a container with the dry spores before the wireworms were introduced into sterilized cans containing moist sand, and by introducing into sterilized cans containing moist sand a small amount of sterilized dry sand mixed with a measured quantity of spores and then putting the worms in the cans. The two methods were about equally effective in securing infection. Check lots of wireworms were kept in cans of moist sand, which had not been inoculated. In one series with *M. anispoliae* Idaho strain six times the usual amount of inoculum increased the mortality of the

wireworms to 57°_{C} compared with 32°_{C} in the cages receiving the usual amount of inoculum.

It was soon noted that in different cages of the same series there was a wide variation in the time required for the wireworms to become infected, and that the wireworms showed infection soon after molting. Apparently the wireworms were susceptible to infection only at the time of ecdysis. Infection and mortality consequently were prolonged over a period of several months after the inoculation of the sand in the cages.

The spores of all species or strains of *Metarrhizium* were dead in old cultures after 18 months.

These infection experiments showed that the Amara strain of *M. anisopliae* had little or no virulence for wireworms. In comparative infection experiments *M. brunneum* showed greater virulence for wireworms than did the Idaho strain of *M. anisopliae*. Although *M. brunneum* had been in artificial culture for 7 years before these experiments were concluded, it showed no impairment of virulence.

The comparative experiments, which were carried on in parallel series from 1937 through 1941, can be summarized as follows: *M. anisopliae* (Idaho strain), 15 series, mean percentage of mortality from fungous infection, $49.5\% \pm 3.9\%$; *M. brunneum*, 12 series, mean percentage of mortality from fungous infection, $72\% \pm 4.6\%$.

These experiments bring out the differences in virulence to wireworms among different species or strains of fungi of the genus *Metarrhizium*, and suggest that it might be worth while to look for strains of entomogenous fungi that are especially virulent to different species of insects. The hyphomycetous fungi have the advantage over the Entomophthoraceae, in that they are easily cultured and their virulence to insects is not impaired by artificial culture over long periods.

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NESTING ACTIVITIES OF TRACHYMYRMEX FOREL (HYMENOPTERA: FORMICIDAE) IN EAST TENNESSEE[1]

A. C. COLE

The genus *Trachymyrmex* is thus far represented from Tennessee by a single form, *T. septentrionalis seminole* Wheeler, one of seven species and subspecies known from the United States. Dennis (1938) records this variety as being very commonly represented in the Mississippi Embayment region of western Tennessee, the only part of the state from which he collected it. The following statements are quoted from the paper by Dennis: "The valley is protected on the north and west by mountains and the temperature is higher than in locations without this protection from the west and northwest storms. This fact probably explains the presence of these species[2] in East Tennessee." C. H. Kennedy took the species in the bottom land of Townsend Valley, east of the Chilhowee Range of eastern Tennessee (Dennis, 1938). The writer found nests of *seminole* in Wears Cove, Great Smoky Mountains National Park, in an open, dry, sandy area comparable to that in which colonies were located by Kennedy.

One might expect colonies of *seminole* to exist in the types of places already mentioned and indeed even at Knoxville, Tennessee, where the writer has noted two nests. However near the very top of Dupont Mountain—a part of the Chilhowee Range having an elevation of 3,600 feet—the writer discovered in July and August, 1949, two flourishing colonies of *seminole*. Temperatures at that elevation are such that the discovery came as a matter of considerable surprise.

At 10:30 A. M., on July 31, 1949, two *seminole* workers were observed on the crest of a rocky north-facing bluff while they were carrying bits of green leaves in their mandibles. The workers were followed to their nest which was located in moist and rather sandy soil beneath the edge of a rocky ledge and was accessible only through a single narrow gallery marked by an inconspicuous, circular, unshaded entrance approximately 0.5 cm. in diameter. The nest contained a fungus garden, with a volume of approximately 23.75 cc., pendent from a root which traversed the length of the single nest chamber. The chamber was situated at a soil depth of 12.5 cm., and it was connected to the nest entrance by a gallery 15.5 cm. in length. The entire nest contents were collected and subsequently examined. The nest site was observed carefully for foraging workers returning to the nest. A total of fourteen ants returned during approximately the first two hours of observation, and inasmuch as no additional ants made an appearance within an additional hour, the writer believes that the entire numerical strength

[2]Dennis includes *Dorymyrmex pyramicus flavus* McCook.

of the colony was represented in the bulk collection. Counts showed a total of 284 workers, 29 alate females, 8 dealate females, 19 larvae, and 67 pupae (chiefly those of workers). No males were in the colony at the time of observation and no male pupae were found. Although eggs were not located, they were undoubtedly in the interstices of the fungus mass and were obscured by the mycelia.

On August 10, 1949, removal of a large imbedded rock from the sandy soil of an open woods on a north-facing slope of Dupont Mountain revealed a nest chamber of *seminole*. This chamber contained a nonpendent fungus garden having a volume of approximately 3.75 cc. The upper surface of the garden was contiguous with an edge of the rock when the latter was in its normal position. This uppermost nest chamber was connected by a gallery 2.5 cm. long to the small nest entrance near an edge of the rock and by a gallery 4.7 cm. long to a second chamber which contained a nonpendent fungus garden having a volume of about 6.53 cc. The second chamber had been constructed at a position horizontal with the first and was located at a depth of 4.8 cm. from the soil surface. A third and much larger nest chamber was lateral to the second one and was connected with it by a gallery 3.2 cm. in length. It was at a depth of 9.7 cm. from the soil surface and contained a pendent fungus mass possessing a volume of nearly 49.90 cc. The entire colony was collected in the manner described for that of the other nest. The nest population consisted of 324 workers (including many callows), 57 alate females, 18 dealate females, 26 larvae, and 84 pupae (63 worker and 21 female). No males or male pupae were in the nest and no eggs were segregated from the fungus mass.

It is of interest to note that although the nest of *seminole* ordinarily has a circlet or semicirclet of detritus surrounding its entrance, in neither case mentioned in this paper was such a device present. Indeed the writer should in all probability not have found the nests had he not observed foraging workers in one instance or removed the rock in the other. The elevation at which the two flourishing colonies were located does not seem to prevent the establishment and survival of colonies of at least hardy *seminole* stock.

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THE CARE AND BREEDING OF LABORATORY ANIMALS, by EDMOND J. FARRIS (Editor). xvi+515 pages, frontispiece plus 174 text figures. John Wiley and Sons, New York. 1950. Price, $8.00.

This work, produced through the collaboration of fifteen specialists in various fields, attempts to give practical rearing methods and procedures for some of the animals more frequently used in experimental work. Those included are the monkey, the rat, experimental mice, the guinea pig, the Syrian hamster, the rabbit, the dog, the domestic cat, ferrets, the opossum, the domestic fowl, reptiles (snakes, lizards, turtles, and crocodilians), Amphibia, laboratory fishes, and *Drosophila*. A final chapter, by W. E. Dove, deals with the control of laboratory pests and parasites of laboratory animals. The usefulness of this work to the entomologist whose teaching or research project requires the rearing of any of the above animals is obvious.—M. T. J.

THE PARASITE COMPLEX OF FURCASPIS OCEANICA LINDINGER[1]

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A survey through the western Caroline Islands including Ulithi Atoll, Yap, and the Palau group showed that the red coconut scale, *Furcaspis oceanica* Lindinger, existed at a low population level. Invariably, the red coconut scale colonies in this area were found to be parasitized by an encyrtid in the genus *Anabrolepis*. These parasites were collected and transported to Saipan, Mariana Islands, where the scale was abundant and without effective natural enemies.

The releases of parasites on Saipan were made in September and November, 1948. The parasites were observed to probe the scales and presumably to oviposit. However, the definite establishment of this parasite on Saipan has not been determined.

A comparative study of specimens of the genotypic species, *Anabrolepis extranea* Timberlake, the oriental species, *A. japonica* Ishii, and *A. bifasciata* Ishii indicated that this parasite of *Furcaspis oceanica* in Micronesia is a new species. It is therefore described as follows.

Anabrolepis oceanica new species
(Figures 1 and 2)

Female.—Head characteristic of genus, subtriangular on lateral view, dorsal and occipital sides of triangular outline nearly equal, facial surface longest; cheeks long; in frontal view head wider than long, outline of eyes and frons forming semicircle; viewed dorsally frontovertex widening posteriorly, occipital ridge with two prominent bristles, each situated near the posterior aspect of the eyes and curving anteriorly toward frontovertex. Ocelli in middle of dorsal part of frontovertex well forward of occipital margin. Mandibles, fig. 2C, apex broad with 2 acute teeth and a broad truncate inner margin. Antennae, fig. 2B, normal for genus, scape very slightly dilated below; pedicel about one-third length of scape, nearly as long as first four funicle segments combined, gradually widening distad, apical width greater than width of following segment; flagellum slightly clavate, first four funicle segments short, transverse, the last two funicle segments distinctly longer than any of the four preceding segments, the sixth segment distinctly the largest of the funicle. Club three-segmented, wider than funicle and approximately of equal length, apex more pointed than round.

Pronotum strongly arcuate; mesoscutum not appreciably convex but rather flat; axillae short, much wider than long, not contiguous at tips; scutellum a little wider than long, sloping sharply downward along lateral margins, the central portion with hexagonal reticulations, scutellum with five pairs of setae, each pair becoming progressively larger and stouter posteriorly; metanotum narrow, nearly obscured by posterior angle of scutellum, a row of three small setae evident on metanotum adjacent to each side of scutellum; propodeum very narrow
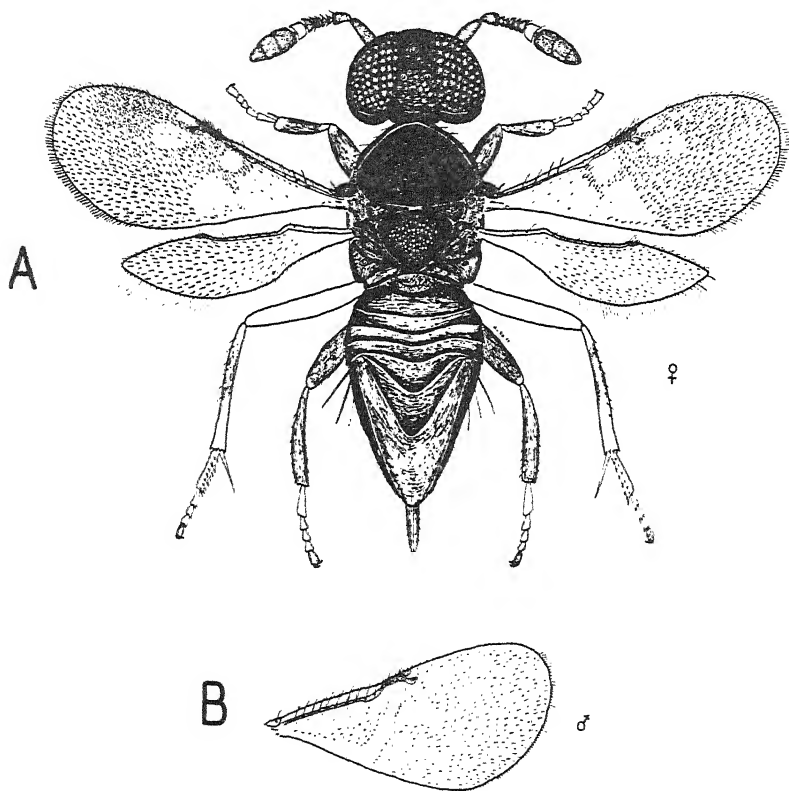
FIG. 1.   *Anabrolepis oceanica*, n. sp.   A. Adult female.   B. Wing of male.

medially, but distinctly enlarging towards sides, spiracles large, conspicuous.

Abdomen long ovate, vibrissal plates on dorsum anterior to middle of abdomen, vibrissae not extending to apex of abdomen.   Ovipositor extended for length equal to length of basitarsus of middle legs.

Legs normal for genus, basitarsal segment of middle pair as long as four subsequent segments combined, slightly longer than saltatorial spur, a row of short stout spines on ventral surface of segment.   Middle tibiae with apical fringe of short stout spines.

Wings of moderate width, extending appreciably beyond apex of abdomen; submarginal vein bears row of four large setae in basal half of its length, slightly swollen distad; marginal vein stout, bearing thick cluster of setae; stigmal vein nearly one-half length of marginal, enlarged at apex; postmarginal short.

Basic color dark brown to black, but head, dorsum of thorax and abdomen with metallic reflections, a blend of greens, deep blues, and purples depending on incidence of light. Scutellum often with distinct golden highlights. Venter except head, chocolate to dark brown.
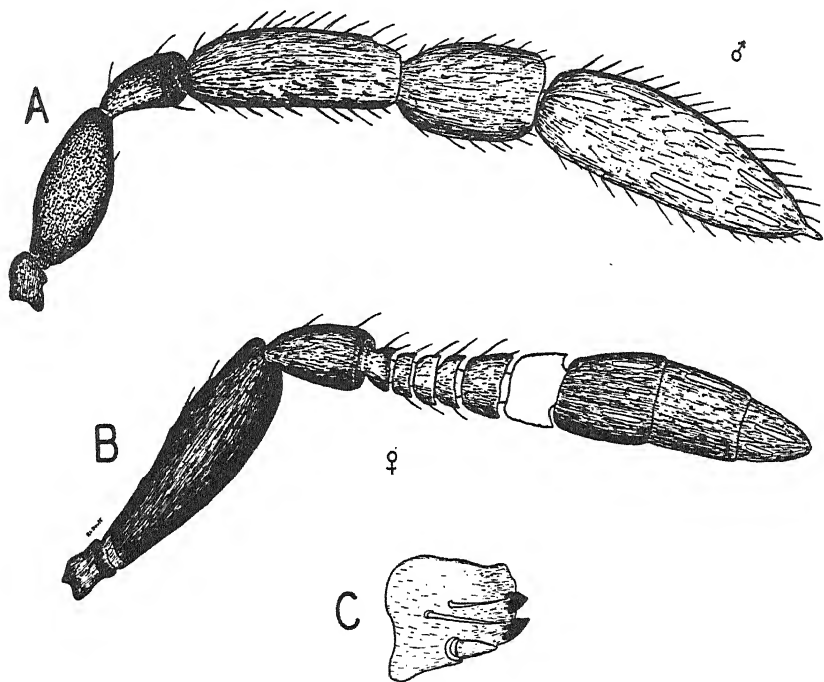
Fig. 2. *Anabrolepis oceanica* n. sp. A. Antenna of male. B. Antenna of female. C. Mandible of female.

Forelegs brown, the tarsi lighter, as are tips of femora and tibiae; middle coxae dark brown, middle femora and tarsi pallid, middle tibiae with band of dark brown; hind legs brown, tarsi lighter, hind femora slightly expanded. Apical tarsal segment of each leg tends to be darker than preceding segments. Antennae black, except sixth funicle segment yellow. Forewings with a large fuscous area interspersed with hyaline spots; the pattern as in fig. 1A, the fuscous area rather indistinctly broken into rays and bands. Posterior wings hyaline.

Male.—Frontovertex very broad, widening both anteriorly and posteriorly, slightly rounded on lateral aspect forming rather soft angles with face and occiput, sculptured with small crowded thimble-like punctures. Pronotum strongly arcuate; mesoscutum flattened, in

some specimens slightly depressed; axillae considerably wider than long, not contiguous at apices; scutellum wider than long, about as female; metanotum and propodeum narrow at apex of scutellum, propodeum strongly enlarging laterally.   Specimens mounted in gum damar show mesophragma to be well developed, larger relatively than in female, broadly rounded, extending into abdomen beyond first abdominal segment.   Abdomen short.

Antennal scape short, swollen, fig. 2A; pedicel longer than wide, about half length of scape; first funicle segment large, wider than pedicel, longer than scape; second funicle segment wider than preceding segment but shorter, nearly equal to scape in length; club solid, widest antennal segment, longer than combined lengths of scape and pedicel, apex with small papilliform projection.   Funicle and club very setaceous.

Wings moderately broad, fig. 1B, oblique hairless streak extending from beneath marginal vein basally toward posterior wing margin. Submarginal vein with numerous stout setae, vein enlarged in distal third; marginal vein very setaceous; post-marginal short; stigmal vein triangularly enlarged at apex.   Wing hyaline except for small fuscous area beneath marginal vein.

General body color dark brown to black.   Head and thorax with metallic purplish highlights in reflected light.   Antennae brown, scape and pedicel darker than funicle and club.   Legs brown, darker than those of female, with tips of femora and tibiae light.   Tarsi of middle legs pallid, apical segment darker.

Holotype.—Female, Potangeras Islet, Ulithi Atoll, Aug. 20, 1948. (R. L. Doutt).   *Allotype.*—Male, Yap, Caroline Islands, Sept. 27, 1948 (R. L. Doutt).   *Paratypes.*—5 females and 15 males, Yap, Oct. 1, 1948 (R. L. Doutt); 11 males, Yap, Sept. 27, 1948 (R. L. Doutt); 3 females and 12 males, Babelthuap, Palau Islands, Oct. 7, 1948 (R. L. Doutt); 1 female and 3 males, Ulithi Atoll, Aug. 20, 1948 (R. L. Doutt).   All specimens reared from *Furcaspis oceanica* Ldgr.

Holotype and allotype deposited in U. S. National Museum.   Paratype series deposited with U. S. National Museum, California Academy of Sciences, and Division of Biological Control, University of California.

Anabrolepis oceanica is most easily distinguished from *A. extranea* Timb., *A. japonica* Ishii, and *A. bifasciata* Ishii by the characteristic wing pattern.

SECONDARY PARASITES

In the Palau Islands, besides the encyrtid *Anabrolpeis oceanica*, a number of specimens of a small aphelinid belonging to the genus *Ablerus* were reared from the same host material.   The status of this parasite could not be definitely determined, but it is presumed to be a secondary. It was always found associated with populations of *Anabrolepis oceanica*.

Ablerus palauensis new species
(Figure 3)

Female.—Frontovertex with inner orbital margins arcuately emarginate, greatest width immediately anterior to lateral ocelli, narrowest width at occipital margin, small setae anterior to lateral ocelli near

margin of eyes. Face deeply impressed, antennae originate low on face. Cheeks long, impressed on upper portion immediately beneath eyes. Frontovertex and upper face yellow, eyes and ocelli bright red; a brilliant white band encircling head including occiput, upper cheeks beneath eyes, face above antennal insertions; this white band bordered beneath by a narrow stripe of black. Clypeus, lower cheeks, and region surrounding mouth parts yellow brown. Mandibles, fig. 3C, with two sharp nearly equal teeth and a third truncate.
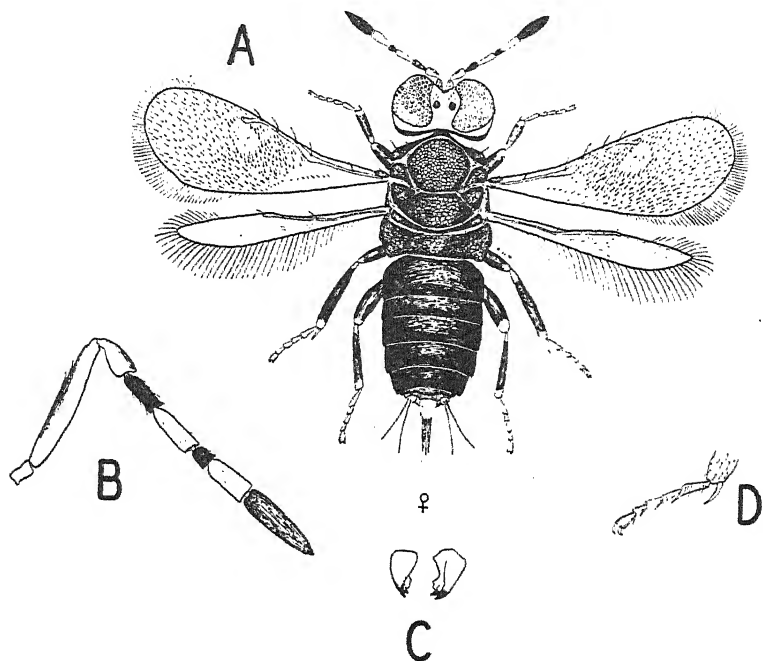
FIG. 3.   A. *Ablerus palauensis*, n. sp., adult female.   B. Details of antenna.
C. Mandibles.   D. Foretarsus.

General body color dark brown to black. Dorsum of thorax with blend of greenish and golden reflections; abdomen with purplish metallic luster. Specimens in alcohol appear to have reticulated sculpturing on mesoscutum, scutellum, and propodeum. In slide mounted specimens these reticulations linear and containing small longitudinal striations forming pattern very like a dactylogram.

Pronotum with two setae on each lateral expansion; mesoscutum with two setae, each located near posterior lateral corners; parapsides with two setae; axilla with a single seta; scutellum with two laterally placed, longitudinal rows of three setae; metanotum with two minute setae on each lateral expansion; propodeum with two setae lateral to each spiracle.

Abdomen with faint reticulate sculpturing; area near cercal plates pallid. Mesophragma extends to middle of abdominal length.

Antennal scape long, cylindrical, fig. 3B, length equal to any three funicle segments; pedicel equal in length to first funicle segment, but wider; second funicle segment cylindrical, longest funicle segment; third funicle segment short, subquadrate; fourth funicle segment subequal to first segment, but wider, width equal to pedicel; club solid, pointed, nearly equal to combined lengths of first two funicle segments, with elongate sensorial pits. Small ring joint present between pedicel and first funicle segment. Antennae yellow-brown except funicles 1, 3, club, and dorsal surfaces of scape and pedicel which are dark brown to black.

Forewings with numerous discal cilia, except distinct oval portion beneath stigmal vein with few cilia, nearly bare, fig. 3A. Distinct fumated cross band extending diagonally and apically from beneath marginal vein toward caudal margin. Marginal cilia moderately long. Submarginal vein with triangular expansion near distal portion; marginal vein with three large setae and several smaller setae dispersed throughout its length; stigmal vein slightly enlarged at apex, somewhat as in *Azotus* group. Posterior wings with long marginal cilia, exceeding width of blade; discal cilia concentrated beneath marginal vein, sparse apically except for row near anterior margin; slightly fumated band beneath marginal vein.

Trochanters white; fore and hind coxae black except at apices which are nearly white, middle coxae white. Femora with center band of black, bases and apices white or pallid. Tibiae dark brown to black, lighter at tips; tarsi light brown except apical segment which is dark. Fore tarsi as in fig. 3D, basal segment with a strigil.

Ovipositor and valves extended, valves black with white tips.

Male.—Similar to female with the following exceptions: Antennal club indistinctly two-segmented, transverse septum difficult to see, segments not articulated, nearly fused; first, second, and fourth funicle segments subequal in length, third funicle segment small, nearly quadrate. Antennal segments brown, concolorous, except funicle segments 2 and 4 which are lighter.

Abdomen relatively shorter than in female, approximately equal to length of thorax.

Holotype.—Female, Babelthuap, Palau Islands, Oct. 7, 1948 (R. L. Doutt). *Allotype.*—Male, Babelthuap, Palau Islands, Oct. 7, 1948 (R. L. Doutt). *Paratypes.*—13 females and 1 male, Babelthuap, Palau Islands, Oct. 7, 1948 (R. L. Doutt). All specimens reared from *Furcaspis oceanica*, but associated with *Anabrolepis oceanica*.

Holotype and allotype deposited in the U. S. National Museum. Paratype series deposited with U. S. National Museum, California Academy of Sciences, and Division of Biological Control, University of California.

Ablerus palauensis sp. n. is perhaps best distinguished by the dense wing ciliation and the conspicuous bare oval area beneath the stigmal vein. The coloration of the head should also be an easy diagnostic character. The antennal structure and shorter setae on marginal vein differentiate it from *macrochaeta* Silvestri. The differences in relative

lengths of the antennal segments separate *palauensis* from *magistrettii* Blanchard. The color of the antennae differentiates this new species from *leucopidis* Blanchard. With reference to the key of Australian species (Girault, 1913) *palauensis* appears to belong with the group including *semifuscipennis* Girault, *bidentatus* Girault, and *nympha* Girault, but may be readily separated from these species by the diagnostic characters given above.

From colonies of *Furcaspis oceanica* collected on Ulithi Atoll there emerged specimens of *Marietta carnesi* (Howard). This parasite is probably a secondary, attacking *Anabrolepis oceanica*. *M. carnesi* has a wide distribution having been previously recorded from Japan, China, India, Delaware, and doubtfully California (Compere, 1936). It is known to attack *Comperiella bifasciata* Howard, a primary parasite of disapine scales which is widespread in Micronesia.

SUMMARY

Populations of the red coconut scale, *Furcaspis oceanica* Ldgr., were found to be suppressed effectively throughout the western Caroline Islands by a new species of Encyrtidae described as *Anabrolepis oceanica*. This parasite was transported to Saipan in an attempt to control the coconut scale on that island.

In the western Caroline Islands two supposedly secondary parasites were found to be associated with the populations of *Anabrolepis oceanica*. These were *Marietta carnesi* (Howard) and a new species of Aphelinidae designated as *Ablerus palauensis*.

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STUDIES HONORING TREVOR KINCAID, by MELVILLE H. HATCH (Editor). University of Washington Press, Seattle. iii+167 pp. 1950. Price, $2.50.

Though he has relatively few publications to his credit (Dr. Hatch lists 22), Dr. Trevor Kincaid has had a profound influence upon the progress of biological science, both theoretical and applied, in the Pacific Northwest. As a teacher, he has inspired students who have carried on the torch of education and research; as a servant of his community, in a scientific way, he has made valuable contributions; and as a broad and tireless collector he has furnished much material to others for taxonomic research. As partial testimony of this last statement, we note a list of 64 organisms which have been named after him; these include a plant, protozoans, coelenterates, annelids, molluscs, arthropods (including 37 insects), a ray, and two fishes.

The present volume consists of eleven papers by former students and associates of Dr. Kincaid. Three of these papers, by Dr. Hatch, are edvoted to the life and work of Dr. Kincaid and of his predecessor and teacher, Orson Bennett Johnson, and to the Young Naturalists' Society, a pioneer organization consisting mostly of amateurs and founded at the time when Seattle was a frontier village, and in which both Kincaid and Johnson took a very active part.

Only one paper in the present volume deals with arthropod taxonomy: "Conopisthine spiders (Theridiidae) from Peru and Ecuador," by Harriet Exline. —M. T. J.

THE GENUS PYCNOPSYCHE (TRICHOPTERA)

CORNELIUS BETTEN

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In our report on the Walker types of Trichoptera in the British Museum, Mosely and I followed an earlier suggestion that it might be well to unite into one genus several North American species of Limnephilidae previously assigned to several genera and differentiated largely by the number of tibial spurs. This paper adds somewhat to the knowledge of these species and confirms the judgment that they should be considered congeneric in *Pycnopsyche* Banks. This genus was described by Banks in 1905 (Trans. Amer. Ent. Soc., 32 : 9), based on *Limnephilus scabripennis* Rambur.

The species of *Pycnopsyche* are, as Trichoptera go, fairly common and conspicuous insects of yellow color with some brown markings, from 15 to 23 mm. in length to the wing tips, occurring as adults in August, September, and October, with a few records in July and November. The larvae also are conspicuous among aquatic insects because of their size and in some species because of a slender stick, sometimes two, or even more, which may be laid alongside the wooden case, projecting beyond the rear end. In the pupal case small stones may replace the wood to some extent, the stick at the end may disappear, and the anterior end is fastened to a submerged stone or often to a submerged branch of a tree or shrub. Not many life histories have been described and even the case-building habits of the various species are not fully known. Larvae of either *P. lepida* or *P. subfasciata* were observed to have the stick attached when the overall length of the case was but 4 or 5 mm. Larvae of *P. gentilis* had cases made of pebbles when observed three or four weeks before pupation and very possibly these have stone cases throughout the larval life. Much may depend on what materials are available.

CHARACTERS COMMON TO THE ADULTS OF PYCNOPSYCHE

Antennae stout, about as long as the wings, yellow or orange in color, sometimes ringed darker, basal joint about equal to the head in length. Head covered with numerous yellow hairs and stouter bristles, the latter arranged in areas often referred to as warts. On either side of the head two such spined areas adjacent to the base of the antenna, a larger one parallel with the posterior margin of the head, and a lunate one posteriorly bordering the eye (figs. 4, 5).

Prothorax with a large area of coarse bristles on either side; on the mesonotum (fig. 8) narrow areas of bristles extend longitudinally on either side of the scutum and scutellum. Legs each with a line of bristles along the coxa, a black spot prominent on the trochanter, the femur almost bare, tibia and tarsus with numerous black spines, hind tarsus with one or more such spines (*P. gentilis* frequently an excep-

tion). Tibial spurs 1-2-2, 1-3-3, or 1-3-4. Wings with surface more or less tuberculate, their shape varying somewhat with the species (figs. 1, 2). Color of the wings yellow to orange, sometimes almost unicolorous but always with brown areas which, in so far as they are present, conform to a common pattern which may include the posterior apical margin, a series of spots in the bases of the apical cells, a transverse band in the middle of the wing, and, less well marked, the posterior margin. One species has prominent round, brown spots on the forewing; in another species the spots are small and not at all conspicuous. Anal area of the hindwings covered with long thin hairs, the amount of the covering differing with the species, more conspicuous in males than in females. Venation as in the figures (figs. 1, 2), the difference between the species not great.

Eighth tergite of the males fairly heavily sclerotized, its dorsal posterior margin often set with short, black spines, the shape and location of these spinose areas being often diagnostic of the species, lower posterior angle of the chitinous shield of this tergite sometimes extended as a hook, point, or rounded knob (figs. 19, 36, 79). Ninth segment strongly sclerotized, its dorsal half often telescoped into the eighth segment; seen from the side it is widest in the middle, tapering dorsally and ventrally (fig. 61). Attached to the dorsal part of the ninth segment there is a paired structure (10 in figs. 61, 63), representing doubtless the tenth segment, consisting ordinarily of a pair of broad lateral pieces (dorsal or superior appendages of McLachlan and others) running mesally into a pair of processes (intermediate appendages), these often curved at the tips; generally a sclerotized area on the surface of the ninth segment connects the tenth segment with the claspers at about the point where the tips of the latter become free, thus the anal aperture is more or less encircled by these structures (fig. 101). Claspers (inferior appendages) in an upright position in relation to the body axis, broadly united to the ninth segment throughout most of their length, the basal part covered with stout bristles; the tips of the claspers, which are free of the ninth segment, variously shaped and often divided (figs. 51, 57, 69, 75). Aedeagus highly characteristic in form, its general structure much the same throughout the genus; arising in a concavity on the dorsal surface are two appendages (titillators) of several types as figured (figs. 13–18).

Female with posterior margin of the seventh ventral segment bordered with fine hairs (fig. 29). Genital opening at the posterior margin of what appears to be the eighth segment; seen from the side its upper and lower lips are conspicuously protruding, the lower lip forming a subgenital plate which may be rounded, mucronate, or lobed, its appearance differing greatly according to the exact line of vision. Dorsally a terminal segment, perhaps a modified ninth and tenth, is sclerotized, sometimes heavily so; seen from above, its rear margin is in many cases slightly cleft (fig. 23). The anal aperture with its surrounding structures differs considerably with the species, often oval in shape (fig. 41), with varying degrees of sclerotization in its margin; in several species the opening is large, almost rectangular (fig. 31). In well-cleared specimens the outline of the spermatheca may be seen through the body wall (figs. 9–12).

RELATIONSHIPS

The genera of Limnephilidae are not readily differentiated, except, as is done in most keys, by the use of a combination of characters which may not be strongly indicative of relationships. For *Pycnopsyche* the most characteristic features are the structure of the aedeagus and the shape and position of the claspers of the male; these latter appendages are flatly joined to the ninth segment for the greater part of their length, the line of fusion remaining well marked. The lower part of the clasper, fused with the ninth segment, is broader from side to side than in the direction of the body axis.

The species of Limnephilidae most closely allied to *Pycnopscyhe* are probably *argus* Harris and *hesperus* Banks which have been listed either in *Astenophylax* or in *Pycnopsyche*, and an undescribed species from Maine given to me by Mr. Nathan Banks. These three species share with *Pycnopsyche* its distinctive type of aedeagus, particularly the subtype whose appendage is a slender stylet (fig. 13). They differ in that they have the line of fusion of the clasper with the ninth segment less well marked, the clasper is not so flatly joined to that segment, and its lower part is without a conspicuous covering of bristles. At least in *argus* (fig. 5) the areas of bristles on the head are more slender. Further, while in *Pycnopsyche* the division of the stem of the vein M in the forewing into M_{1+2} and M_3 is at the level of the middle of the discal cell, in these species it is much nearer to the distal end of that cell (figs. 6, 7). In the three species referred to a cross vein is often, though not invariably, present between Sc and R, of the hindwing (fig. 3); this vein does not occur in *Pycnopsyche*. In the females of the three related species an anal tube (figs. 76, 77, 78) is more strongly developed than in any species of *Pycnopsyche*.

Within the genus *Pycnopsyche* there are few clear indications of subsidiary groupings. The genus *Allegophylax*, set up by Banks for *lepida* and *subfasciata* (and by later addition, *indiana*) is a natural unit agreeing in having spurs 1-2-2, as well as in the structure of the genitalia. The species *aglona*, *limbata*, and *sonso* are strikingly alike in respect of the structures terminating the female abdomen; *limbata* and *sonso* agree in having the mesal arms of the tenth male segment greatly elongated, apparently horizontal in *limbata* (figs. 19, 25), more upright in *sonso* (fig. 26); these appendages are largely fused in the middle line in *sonso* (fig. 32); *limbata* is divergent from all other species in the structure of the ninth segment of the male (fig. 19), and in the form of the appendages of the aedeagus (fig. 14); *gentilis* and *flavata* are similar in respect of the appendages of the aedeagus (figs. 15, 17); *guttifer, divergens, circularis,* and *rossi* have spurs 1-3-3. But none of these things seems very conclusive.

The more important characters of the species are sufficiently indicated in the keys that follow and in the figures. A few notes, mainly on distribution, are added.

Unfortunately most of the characters used in the keys cannot be readily seen except in specimens that have been expanded and cleared in KOH.

KEY TO MALES OF THE GENUS PYCNOPSYCHE

1. Mesal arms of the tenth segment long and slender, extending well beyond
   the tips of the claspers either caudally if in a horizontal position or
   dorsally if vertical (figs. 19, 26)......................................2
   Mesal arms of the tenth segment inconspicuous or heavy, often more or less
   hidden by the side pieces of the segment, not long and slender............3
2. Anterior margin of the ninth segment, seen from the side, sharply curved to
   almost a right angle (fig. 19). Appendages of the aedeagus with basal
   stem longer than the terminal division which is single and ribbon-like
   (fig. 14). Mesal arms of the tenth segment separate through most of
   their length (fig. 25)...**limbata**
   Anterior margin of the ninth segment not curved to nearly a right angle.
   Appendages of the aedeagus terminated by a stylet, not flat, ribbon-like.
   Mesal arms of the tenth segment fused through most of their length
   (fig. 32)...**sonso**
3. Posterior margin of the eighth tergite laterally produced into a rounded lobe
   densely covered with short black spines (fig. 36)........................4
   Posterior margin of the eighth tergite not produced or, if so, not into a
   rounded scabrous lobe..7
4. Posterolateral scabrous lobe of the eighth tergite near the ventral margin of
   that tergite (figs. 33, 36). Appendages of the aedeagus terminated by a
   group of several bristles (figs. 16, 18).................................5
   Posterolateral lobe of the eighth tergite near the middle of that tergite as
   seen from the side (fig. 42). Appendages of the aedeagus terminated by
   a single stylet..6
5. Tenth segment with mesal arms heavy and prominent (fig. 33). Main tip
   of the clasper blunt, with a small inner tooth (figs. 33, 35). Field of
   spines on the eighth tergite extending across that tergite (fig. 34). Spurs
   1–3–4...**aglona**
   Mesal arms of the tenth segment not prominent (fig. 36). Tip of the clasper
   obtusely pointed (fig. 38). Field of spines on the eighth tergite largely
   limited to the mid-dorsal region (fig. 37). Spurs 1–3–3............**guttifer**
6. Forewings with many conspicuous, round, brown spots of varying size.
   Claspers indented or cleft at tip, not running into a sharp point (figs.
   44, 48). Spurs 1–3–4...**scabripennis**
   Brown spots on the forewings small and not conspicuous. Claspers ending
   in a single sharp point (fig. 51). Spurs 1–3–3.......................**rossi**
7. Tips of the claspers not reaching above the level of the tenth segment.
   Spurs not 1–2–2..8
   Tips of the claspers long, extending well above the tenth segment (figs.
   85, 91). Spurs 1–2–2..12
8. Spurs 1–3–3...9
   Spurs 1–3–4..10
9. Posterior margin of the eighth tergite, seen from above, trilobed (fig. 56).
   Tips of the claspers divided (fig. 57)..............................**circularis**
   Posterior margin of the eighth tergite not trilobed. Tips of the claspers
   not divided..**divergens**
10. Appendages of the aedeagus stout, terminated by a group of spines (figs.
    15, 17)...11
    Appendages of aedeagus slender, terminated by a single stylet (fig. 79)...**luculenta**
11. A conspicuous area of black spines in the middle of the rear margin of the
    eighth tergite (figs. 67, 68).......................................**gentilis**
    No conspicuous area of black spines on the eighth tergite...........**flavata**
12. Posterior margin of the eighth tergite, viewed from above, with a heavy
    border of black spines, this border with a distinct mesal notch (fig. 86), **lepida**
    Posterior margin of the eighth tergite with black spines which are segre-
    gated most heavily in two roughly triangular areas; no distinct notch in
    the border (fig. 92)...13
13. Posterolateral margin of the eighth tergite notched but not produced into a
    hook. Claspers with an abrupt shoulder setting off the slender tip. Aedeagus
    stocky, the tip of its appendage twice as long as its base (fig. 97)......**indiana**
    Posterolateral margin of the eighth tergite commonly produced into a hook
    (figs. 91, 103). Claspers generally narrowed gradually to the tips (fig. 93).
    Aedeagus slender, the terminal part of its appendage three times as long as
    its base..**subfasciata**

KEY TO FEMALES OF THE GENUS PYCNOPSYCHE[1]

1. Spurs 1-2-2. Terminal segment with either two or three processes arising
   from the dorsal margin (figs. 89, 90, 95, 96)..........................11
   Spurs not 1-2-2. Terminal segment without dorsal processes..............2
2. Posterior margin of the terminal segment, seen from above, abruptly con-
   cave (fig. 30). Anal aperture broad, roughly rectangular (fig. 31).........3
   Posterior margin of the terminal segment, seen from above, not concave.
   Anal aperture not very broad, not rectangular...........................4
3. Small species, about 15 mm. to the wing tips. Reported from northern
   states..**aglona**
   Larger species, 17-20 mm. to the wing tips. Reported from North Car-
   olina..**sonso**
4. Lower lip of the anal aperture, seen from below, broadly U-shaped, the
   sides of the opening not sclerotized (fig. 24). Terminal segment, seen
   from the side, runs out dorsally into a sharp point (fig. 22). Length to
   wing tips about 15 mm..**limbata**
   Anal aperture not as above. Terminal segment not sharply pointed.
   Length to wing tips at least 17 mm....................................5
5. Forewings conspicuously marked with many round, brown spots..**scabripennis**
   No round brown spots on the forewings, or, if present, small and not
   conspicuous...6
6. Spurs 1-3-3...7
   Spurs 1-3-4..10
7. Dorsal margin of the terminal segment, viewed from the side, curved sharply
   downward to its apex (figs. 52, 58)....................................8
   Dorsal margin of the terminal segment not curved sharply downward........9
8. Subgenital plate with a small middle lobe in its free margin (fig. 60). Lower
   side of the anal tube sclerotized so as to form an oblique, flat floor
   beneath (fig. 58)...**circularis**
   Subgenital plate rounded or mucronate. Floor of the anal tube not
   sclerotized..**rossi**
9. Terminal segment very heavily sclerotized, almost square in lateral view.
   Upper cleft lip extends beyond the remainder of the segment (fig. 64),
   divergens[2]
   Terminal segment not very heavily sclerotized, tapering, the upper and
   lower lips of the anal tube about equally extended (fig. 39)........**guttifer**
10. Subgenital plate distinctly trilobed (fig. 72). Between the anal aperture
    and the genital plate a transverse rectangular field covered with small
    spines except in the median line (fig. 72).........................**gentilis**
    Subgenital plate with evenly rounded or slightly mucronate margin.
    Between the anal aperture and the genital plate two rounded areas of
    small spines (fig. 84)..**luculenta**
11. Terminal segment with a process at either side dorsally, but none in the
    mesal line (figs. 89, 90)...**lepida**
    Terminal segment with a mesal and two lateral processes (figs. 95, 96),
    subfasciata, indiana

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[1]The females of *P. aglona* and *P. flavata* are not yet known.
[2]See notes on this species.

EXPLANATION OF PLATE I

Venation of wings: Fig. 1. *P. scabripennis* Rambur. Fig. 2. *P. subfasciata*
Say. Fig. 3. *Astenophylax argus* Harris. Dorsal view of head: Fig. 4. *P. flavata*
Banks. Fig. 5. *Astenophylax argus* Harris. Detail of venation of forewing:
Fig. 6. *P. guttifer* Walker. Fig. 7. *Astenophylax hesperus* Banks. Dorsal view
of mesothorax: Fig. 8. *Pycnopsyche* sp. Spermatheca: Fig. 9. *P. gentilis*
McLachlan. Fig. 10. *P. luculenta* Betten. Fig. 11. *P. guttifer* Walker. Fig. 12.
P. limbata McLachlan. Aedeagus: Fig. 13. *P. lepida* Hagen. Fig. 14. *P. limbata*
McLachlan. Fig. 15. *P. flavata* Banks. Fig. 16. *P. aglona* Ross. Fig. 17. *P.*
gentilis McLachlan. Fig. 18. *P. guttifer* Walker.

PLATE I

Genus Pycnopsyche
Cornelius Betten
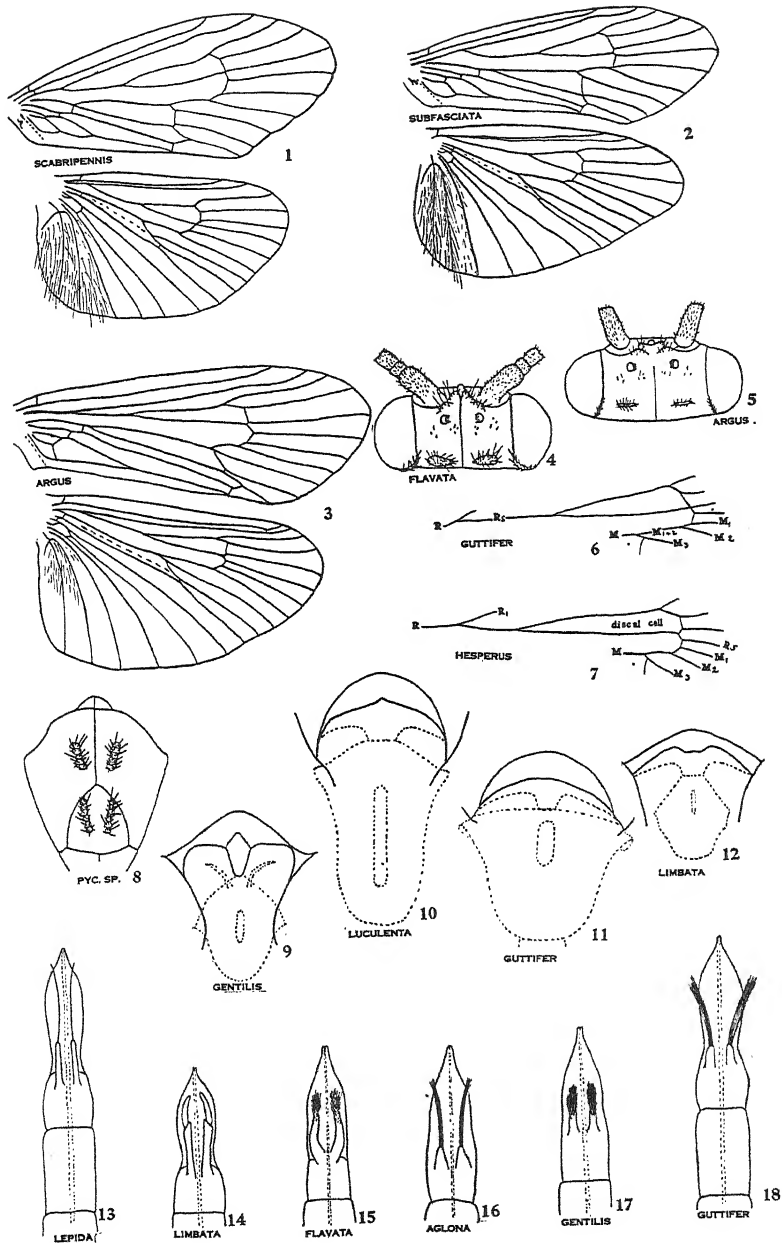
Pycnopsyche aglona Ross

Figs. 16, 33–35

1941. *Pycnopsyche aglonus* Ross, Canad. Ent., 73: 18, fig. 6.
1944. *Pycnopsyche aglona* Ross, Bull. Ill. Nat. Hist. Surv., 23: 299 (listed).

This species was described from specimens taken in Ontario (August) and Massachusetts, and is reported also from Maine and from Pinnacle Mt., N. Y. (Sept. 14). Two male specimens taken in northern Wisconsin (Aug. 29) have the basic color pattern of the genus well marked, particularly in the apical part of the forewing.

This species and *limbata* can ordinarily be separated from the others by their small size (about 15 mm.), but small sized individuals occur in other species. The massive dorsal appendages of the male are rather distinctive.

The female of *aglona* has not been described; a female specimen from Norway, Maine, in the Museum of Comparative Zoology at Cambridge, Mass., apparently belonging here, seems to have terminalia of the same type as those of *sonso*.

Pycnopsyche circularis Provancher

Figs. 55–60

1877. *Platyphylax circularis* Provancher, Nat. Canad., 9: 260.
1878. *Platyphylax circularis* Provancher, Petite Fauna Ent. Can., p. 135.
1935. *Stenophylax circularis* Milne, St. N. Amer. Trich. 2: 33, 52.
1944. *Pycnopsyche circularis* Ross, Bull. Ill. Nat. Hist. Surv., 23: 299 (listed).

The male of this species is distinguished by having the posterior margin of the eighth tergite, as seen from above, divided into three spinose lobes; these latter are dorsal rather than lateral and, in the use of the key for the determination of the species, are therefore not likely to be confused with the more lateral scabrous areas shown by males of *guttifer*, *scabripennis*, and other species.

Dr. H. H. Ross kindly lent me a male and a female specimen, collected at Bayfield, Wis., on August 26. I have in addition incomplete specimens from Piseco Lake and Keene Valley, N. Y., also taken in August. Provancher's material was from Quebec and the species is further reported from Maine (Sept. 17), New Hampshire, Massachusetts, and Rhode Island. The male specimen from Wisconsin measures 20 mm. and the female is slightly larger.

Pycnopsyche divergens Walker

Figs. 61–66

1852. *Limnephilus divergens* Walker, Cat. Neur. Brit. Mus., p. 30.
1863. *Anabolia divergens* McLachlan, Ent. Ann., pp. 156, 161.
1864. *Stenophylax divergens* Hagen, Verh. Zool. Bot. Ges. Wien, 14: 855 (listed)
1926. *Halesus dan* Sibley, Jour. N. Y. Ent. Soc., 34: 81.
1926. *Halesus dan* Sibley, Bull. Lloyd Library, No. 27, Ent. Ser., 5: 107, pl. 10, fig. 71.
1934. *Halesus* sp. Betten, N. Y. Mus. Bull., 292: 350, pl. 49, figs. 12, 13.
1935. *Stenophylax dan* Milne, St. N. Amer. Trich., 2: 33, 52.
1940. *Pycnopsyche divergens* Betten and Mosely, Walker types of Trichoptera, p. 146, fig. 73 (*dan* reduced to synonymy).

Originally described from North America, this species is reported only from New York (McLean, Voorheesville, Rochester, Aug. 20–Sept. 22).
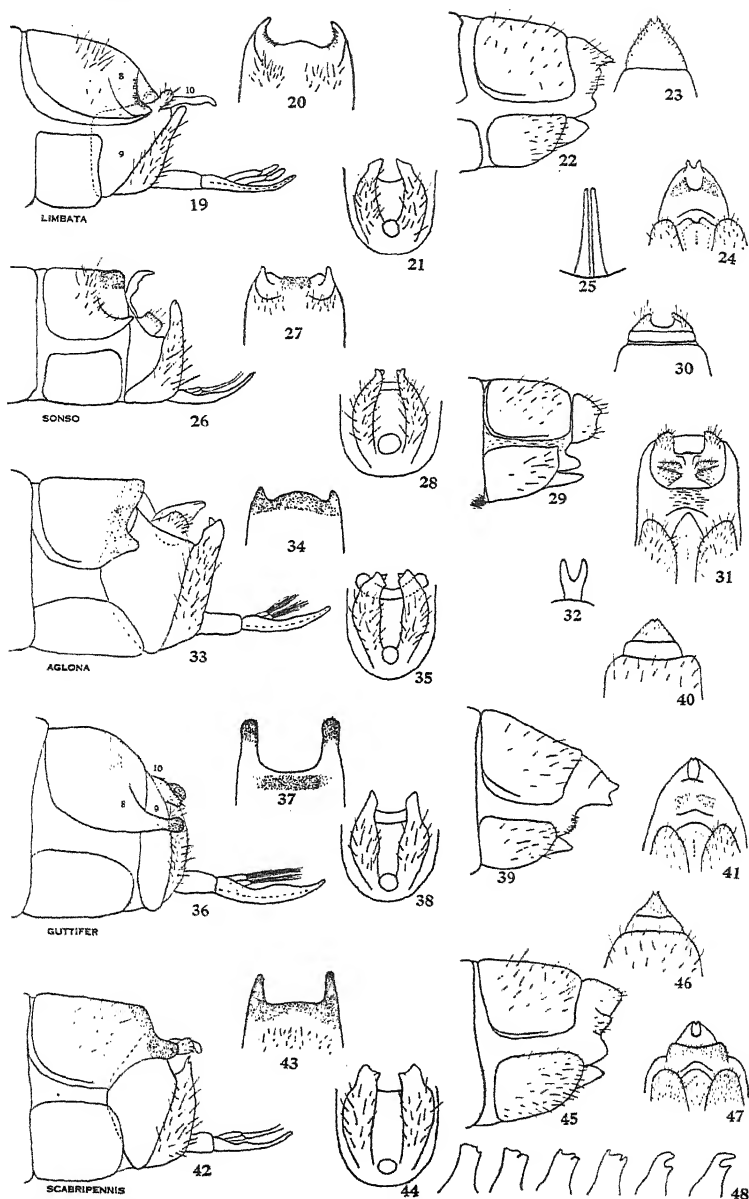
Lateral, dorsal, and ventral views of genitalia and terminal structures.

Figs. 19–21, 25. *P. limbata* McLachlan, male. Figs. 22–24. *P. limbata* McLachlan, female. Figs. 26–28, 32. *P. sonso* Milne, male. Figs. 29–31. *P. sonso* Milne, female. Figs. 33–35. *P. aglona* Ross, male. Figs. 36–38. *P. guttifer* Walker, male. Figs. 39–41. *P. guttifer* Walker, female. Figs. 42–44. *P. scabripennis* Rambur, male. Figs. 45–47. *P. scabripennis* Rambur, female. Fig. 48. *P. scabripennis* Rambur, variations in tip of clasper.

It should be said that the determination of the single incomplete specimen from which the figures of the female genitalia were made is open to question.   The specimen was taken at Voorheesville, N. Y., on August 30, 1923.   It is here assigned to *divergens* largely by the exclusion of other possibilities.   The middle and hind legs of the specimen are lacking so that even the partial confirmation by spur formula is not possible.

Pycnopsyche flavata Banks
Figs. 4, 15, 73-75

1914.   *Stenophylax flavata* Banks, Can. Ent., 46: 154, pl. 10, figs. 32, 33.
1944.   *Pycnopsyche flavata* Ross, Bull. Ill. Nat. Hist. Surv., 23: 299 (listed).

This species is so far reported only from the mountains of North Carolina (July 11, Aug. 18).   I have examined the type in the Cambridge Museum of Comparative Zoology and several male specimens lent to me by Dr. D. G. Denning of the University of Wyoming and by the Department of Entomology of the University of Minnesota.   The males measure 20 mm. to the wing tips.   The female is not described.

Pycnopsyche gentilis McLachlan
Figs. 9, 17, 67-72

1871.   *Stenophylax gentilis* McLachlan, Jour. Linn. Soc. London, Zool., 11: 108.
1916.   *Eustenace gentilis* Banks, Can. Ent., 48: 122.
1926.   *Stenophylax gentilis* Sibley, Bull. Lloyd Library, No. 27, Ent. Ser. 5:107, 218, figs. 100-102, 109.
1934.   *Stenophylax gentilis* Betten, N. Y. State Mus. Bull., 292: 342, pl. 48, figs. 3, 4.
1943.   *Pycnopsyche perplexa* Banks *nec* Betten and Mosely, Harvard Mus. Comp. Zool., Bull., 92: 346, fig. 35.
1944.   *Pycnopsyche gentilis* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 299 (listed).

The male of this species is easily recognized by the median scabrous area on the rear margin of the eighth tergite and by the heavy appendages of the aedeagus.   The female has the subgenital plate more distinctly trilobed than any other species.   The wings of this rather large species are shiny and transparent, the veins of the anastomosis, particularly in its posterior part, are darker than the remainder of the venation and stand out because of the lack of color in the wings.

The species is reported from Nova Scotia, New York (Aug. 22-Sept. 28), from most of the northeastern states, Pennsylvania, New Jersey, North Carolina, and Georgia (Oct. 23).

Pycnopsyche guttifer Walker
Figs. 6, 11, 18, 36-41

1852.   *Halesus guttifer* Walker, Cat. Neur. Brit. Mus., p. 16.
1906.   *Halesus guttifer* Ulmer, Notes Leyden Mus., 28: 24, figs. 30, 31.
1907.   *Pycnopsyche guttifer* Banks, Proc. Ent. Soc. Wash., 8: 122, pl. 9, fig. 22.
1907.   *Pycnopsyche similis* Banks, Proc. Ent. Soc. Wash., 8: 122, pl. 9, fig. 25.
1934.   *Halesus guttifer* Betten, N. Y. State Mus. Bull., 292: 348, pl. 49, figs. 9-11.
1935.   *Stenophylax guttifer* Milne, St. N. Amer. Trich., 2: 33 (*similis* reduced to synonomy).
1938.   *Stenophylax guttifer* Ross, Psyche, 45: 41 (male lectotype of *similis* designated).
1940.   *Pycnopsyche guttifer* Betten and Mosely, Walker types of Trichoptera, p. 150, figs. 75, 76.
1944.   *Pycnopsyche guttifer* Ross, Bull. Ill. Nat. Hist. Surv., 23: 196, figs. 676, 680.
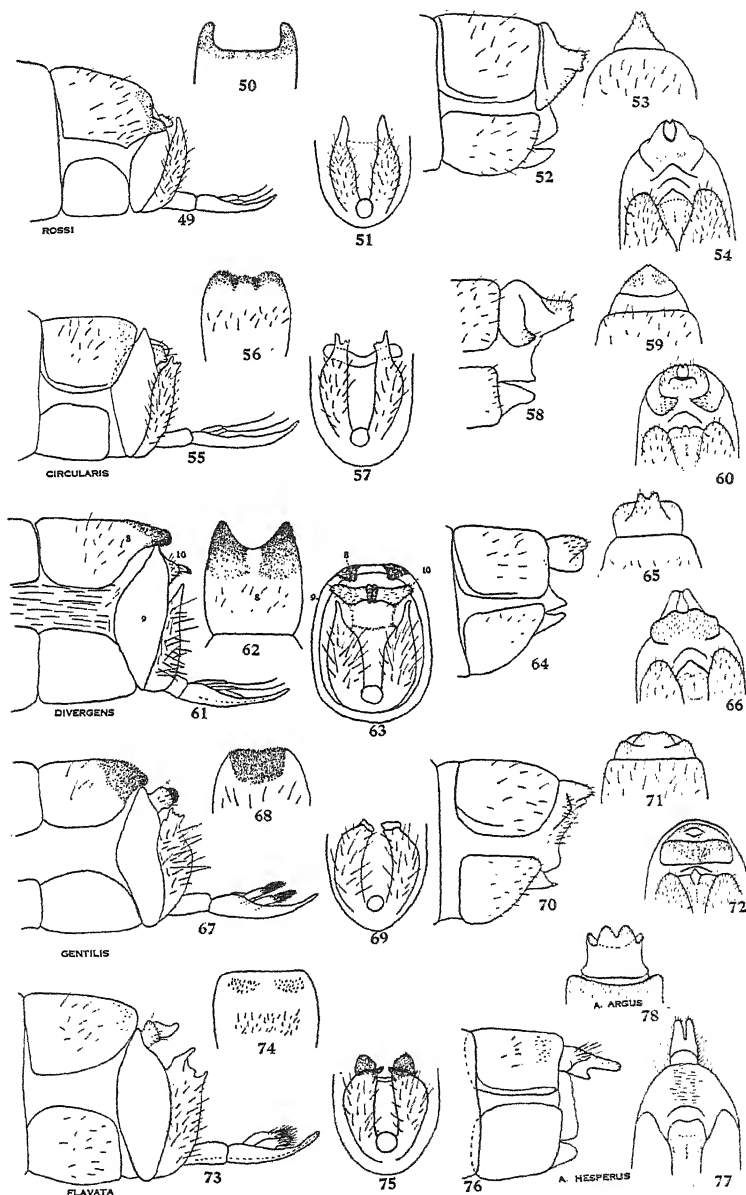
Genital and terminal structures.

Figs. 49–51. *P. rossi* n. sp., male. Figs. 52–54. *P. rossi* n. sp., female. Figs. 55–57. *P. circularis* Provancher, male. Figs. 58–60. *P. circularis* Provancher, female. Figs. 61–63. *P. divergens* Walker, male. Figs. 64–66. *P. divergens* Walker, female. Figs. 67–69. *P. gentilis* McLachlan, male. Figs. 70–72. *P. gentilis* McLachlan, female. Figs. 73–75. *P. flavata* Banks, male. Figs. 76, 77. *Astenophylax hesperus* Banks, female (lateral and ventral). Fig. 78. *Astenophylax argus* Harris, female (dorsal).

This species ranks with *gentilis* and *scabripennis* as the largest in the genus; as in the latter species the forewing is wide in proportion to length. The scabrous projection of the side of the eighth tergite will readily serve for identification of the male. The species is widely distributed, being reported from Nova Scotia, the northern states as far west as Montana and Wyoming, and also from Tennessee, Georgia, Pennsylvania, and Louisiana. The dates of capture noted for New York State run from July 28 to September 29.

The rearing of specimens collected in the Davidson River near Ecusta, North Carolina confirms the assumption that the two females associated with the male type in the Walker collection (Betten and Mosely, 1940, Walker types of Trichoptera, p. 153) are correctly placed.

Pycnopsyche indiana Ross
Figs. 97–100

1938.   *Stenophylax indiana* Ross, Proc. Ent. Soc. Wash., 40: 121, fig. 10.
1944.   *Pycnopsyche indiana* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 196, figs. 674B, D, E, F, 681A.

The specimens on which the original description is based are from Indiana and Ohio (Sept. 15–Oct. 7). Dr. Ross has lent me a paratype from Ohio and also male specimens from Georgia that seem to be the same. The males are like those of *subfasciata* in the dorsal aspect of the eighth tergite but are differentiated by a stockier aedeagus, and the clasper has a more abrupt shoulder setting off the tip than is commonly found in *subfasciata*. The two species need further study as the characters used may be subject to some degree of variation.

Pycnopsyche lepida Hagen
Figs. 13, 85–90, 101, 102

1861.   *Enoicyla lepida* Hagen, Syn. Neur. N. Amer., p. 269.
1871.   *Platyphylax lepidus* McLachlan, Jour. Linn. Soc. London, Zool. 11: 110.
1916.   *Allegophylax lepidus* Banks, Can. Ent., 48: 122.
1934.   *Platyphylax lepidus* Betten, N. Y. State Mus. Bull., 292: 350, pl. 50, figs. 4–6.
1935   *Stenophylax lepidus* Milne, St. N. Amer. Trich., 2: 32, 52 (listed as synonym of *subfasciata*).
1938.   *Stenophylax lepidus* Ross, Psyche, 45: 41 (lectotype set).
1940.   *Allegophylax lepidus* Betten and Mosely, Walker types of Trichoptera. p. 153, figs. 77, 78.
1944.   *Pycnopsyche lepida* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 195, fig. 673.

The surest recognition mark of the male of this species seems to be the decided notch in the middle of the posterior margin of the eighth tergite (fig. 86). In *subfasciata* and *indiana*, related species, the scabrous margin of the tergite is continuous and shows two mesal roughly triangular darker areas.

The species is reported from the northeastern states generally, from New York (Aug. 13–Oct. 20), New Jersey, Pennsylvania, Virginia, West Virginia, North Carolina, Georgia, Michigan, Wisconsin, and Illinois.

Dr. J. W. Leonard of the Michigan Institute of Fisheries Research has given me the opportunity of examining a very large number of specimens taken from the Ausable and Marquette Rivers in Michigan and in these the characters here used in the keys appear to be constant.
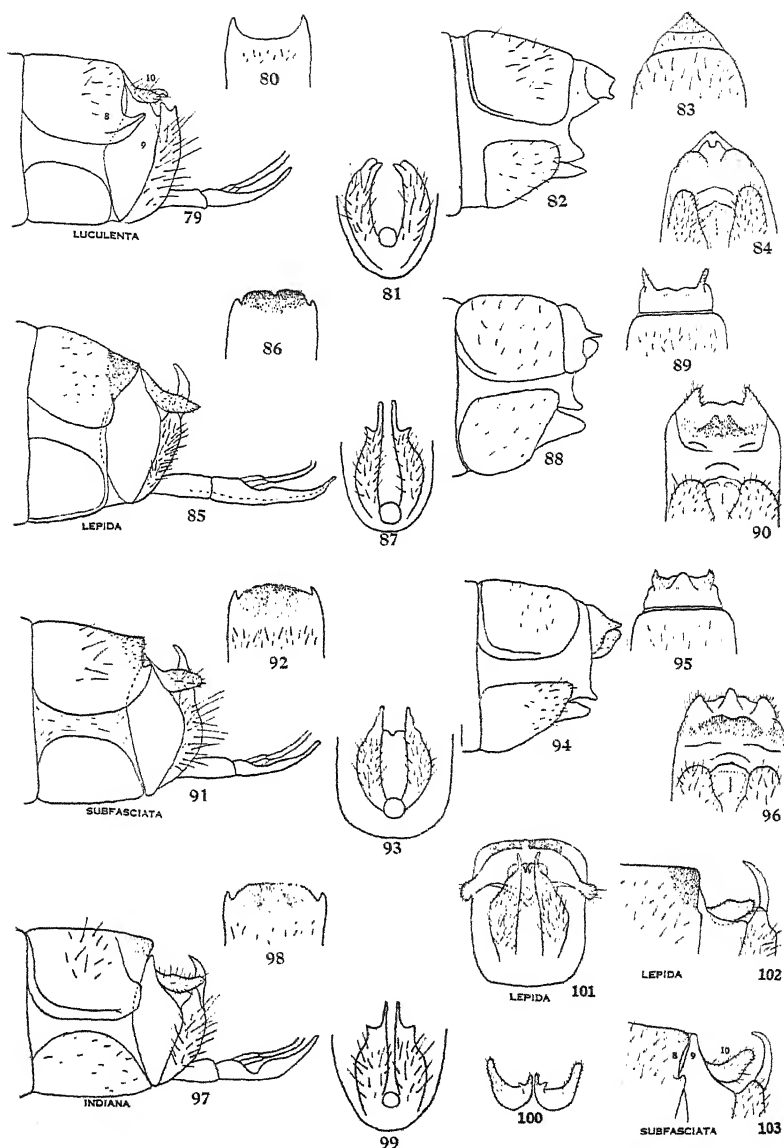
Genital and terminal structures.

Figs. 79–81. *P. luculenta* Betten, male. Figs. 82–84. *P. luculenta* Betten, female. Figs. 85–87. *P. lepida* Hagen, male. Figs. 88–90. *P. lepida* Hagen, female. Figs. 91–93. *P. subfasciata* Say, male. Figs. 94–96. *P. subfasciata* Say, female. Figs. 97–99. *P. indiana* Ross, male. Fig. 100. *P. indiana* Ross, tenth segment, dorsal. Fig. 101. *P. lepida* Hagen, male (caudal). Fig. 102. *P. lepida* Hagen, male, tenth segment (lateral). Fig. 103. *P. subfasciata* Say, male, tenth segment (lateral).

Pycnopsyche limbata McLachlan
Figs. 12, 14, 19–25

1871. *Stenophylax limbatus* McLachlan, Jour. Linn. Soc. London, Zool., 11: 108, pl. 2, fig. 2.
1916. *Eustenace limbatus* Banks, Can. Ent., 48: 118, 122.
1934. *Stenophylax limbatus* Betten, N. Y. State Mus. Bull., 292: 344, pl. 48, figs. 5, 6.
1935. *Eustenace limbatus* Milne, St. N. Amer. Trich., 2: 50 (genotype of *Eustenace*).
1944. *Pycnopsyche limbata* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 299 (listed).

This is a small, rather well marked species that differs from all the others in having the anterior margin of the ninth male segment sharply angled and also in that the appendages of the aedeagus are flat at the distal end, not tipped with a stylet or with spines. It is reported from New York (July 30–Sept. 17), Rhode Island, the northeastern states generally, and from Quebec, Nova Scotia, Newfoundland, and Ontario.

Pycnopsyche luculenta Betten
Figs. 10, 79–84

1934. *Stenophylax luculentus* Betten, N. Y. State Mus. Bull., 292: 345, pl. 48, figs. 7–12, pl. 49, figs. 1–4.
1944. *Pycnopsyche luculenta* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 196, figs. 677 C, E, 679 B, C.

This is one of the larger species (19–20 mm.). It is reported from New York (Aug. 2–Sept. 21), Maine, New Hampshire, Massachusetts, Pennsylvania, North Carolina, Indiana, and Wisconsin.

Pycnopsyche rossi n. sp.
Figs. 49–54

Color brownish yellow; eyes, a spot on each trochanter, and the spines on the legs, black, as in other species in the genus. Forewings with apical margin of dark brown beginning with cell R_3 and extending around to the tips of the anal veins; the brown color follows along Cu_1 toward the base of the wing; dark spots also in the bases of some of the apical cells and a dark patch runs transversely across the middle of the wing into the discal cell, enclosing the bulla on the main stem of M. Many minute brown spots on the wing surface, not conspicuous as in *scabripennis*.

Male genitalia like those of *aglona*, *guttifer*, and *scabripennis* in having the lateral margin of the shield of the eighth tergite produced into a rounded scabrous point; an area of black spines is continuous along the posterior margin of the eighth tergite, not limited to the mid-dorsal area as in *guttifer*; the appendages of the aedeagus of the type common to *scabripennis*, *luculenta*, and other species, the slender stylet at the end about two times the length of its base. The female has the terminal segment of the abdomen sclerotized, its dorsal margin, as seen from the side, curved downward sharply (fig. 52); the apical cleft in the margin of this segment is very small.

Length, male and female, 17 mm. Tibial spurs 1–3–3.

The holotype male, the allotype, and a female paratype, all taken at McCann Spring, Wolf Lake, Illinois, on October 6, 1947, are deposited in the collection of the Illinois State Natural History Survey at Urbana, Illinois. Dr. H. H. Ross kindly placed these specimens at my disposal and suggested that their description be included in this paper.

Pycnopsyche scabripennis Rambur

Figs. 1, 42–48

1842. *Limnephilus scabripennis* Rambur, Hist. Nat. Insect. Neurop, p. 488.
1852. *Neuronia antica* Walker, Cat. Neur. Brit. Mus., p. 9.
1861. *Hallesus scabripennis* Hagen, Syn. Neur. N. Amer., p. 265 (*antica* reduced to synonomy).
1905. *Pcynopsyche scabripennis* Banks, Trans. Amer. Ent. Soc. 32: 9 (genotype).
1907. *Pycnopsyche scabripennis* Ulmer, Cat. Coll. Zool. Selys Longchamps, 6: 26, figs. 45, 46, pl. 2, fig. 8.
1907. *Pycnopsyche scabripennis* Ulmer, Gen. Insect., Fasc. 60, pl. 4, fig. 28, pl. 33, fig. 1.
1921. *Pycnopsyche scabripennis* Lloyd, Bull. Lloyd Library, 21: 60, figs. 88–95 (immature stages).
1926. *Pycnopsyche scabripennis* Sibley, Bull. Lloyd Library, 27: 108, 219, pl. 12, fig. 95 (immature stages).
1934. *Stenophylax scabripennis* Betten, N. Y. State Mus. Bull., 292: 345, pl. 49, figs. 5–8.
1940. *Pycnopsyche antica* Betten and Mosely, Walker types of Trichoptera, p. 145, fig. 72.
1940. *Pycnopsyche perplexa* Betten and Mosely, l. c., p. 149, fig. 74.
1943. *Pycnopsyche scabripennis* Banks, Bull. Mus. Comp. Zool., 92: 344, fig. 42.
1943. *Pycnopsyche antica* Banks, l. c., p. 344, figs. 30–32.
1943. *Pycnopsyche minima* Banks, l. c., p. 345, figs. 38, 39.
1943. *Pycnopsyche conspersa* Banks, l. c., p. 345, figs. 45, 46.
1944. *Pycnopsyche antica* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 196, figs. 678 C, E, 683 A.

A satisfactory analysis of the *scabripennis* complex still awaits further collection and rearing of specimens. The Rambur type is a female without abdomen, recognizable by the heavily spotted wings. The type of *antica* is also a female. Betten and Mosely doubtfully set off *perplexa* because in the female type specimen the dark spots on the wings are small and less conspicuous than in *scabripennis* generally. Banks separated *minima* mainly by its size, and *conspersa* by the shape of the tip of the clasper. With respect to the character just mentioned it may be noted that there is variation in the extent to which the tip is divided (fig. 48) and the appearance differs greatly with the angle of vision. My judgment remains tentative to the effect that the forms designated *antica*, *perplexa*, *minima*, and *conspersa* will not prove to be of full specific standing.

As *scabripennis* the insect is reported from Quebec, the eastern states as far south as Georgia, and from as far west as Michigan.

Pycnopsyche sonso Milne

Figs. 26–32

1933. *Allegophylax subfasciata* Carpenter *nec* Say, Psyche, 40: 34.
1935. *Stenophylax sonso* Milne, St. N. Amer. Trich., 2: 32.
1944. *Pycnopsyche sonso* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 299 (listed).

The male of this species is easily recognized by the long mesal arms of the tenth segment, fused except at the tip and extending above the lateral pieces of the segment (figs. 26, 32).

Listed from North Carolina and Tennessee, August, September. In a considerable number of specimens reared from the Davidson River in the Pisgah National Forest the dates of emergence range from September 19 to September 30.

Pycnopsyche subfasciata Say

Figs. 2, 91–96, 103

1824.   *Phryganea subfasciata* Say, Narrative of Long's Expedition, 2: 308.
1828.   *Phryganea subfasciata* Say, Amer. Ent., 3, pl. 44.
1859.   *Phryganea subfasciata* Say, Complete Writings, p. 97, pl. 44, fig. 3.
1861.   *Enoicyla subfasciata* Hagen, Syn. Neur. N. Amer., p. 269.
1871.   *Platyphylax subfasciatus* McLachlan, Jour. Linn. Soc. London, Zool. 11: 110.
1907.   *Platyphylax subfasciatus* Ulmer, Coll. Zool. de Selys Longchamps, 6: 25, figs. 40–44.
1907.   *Platyphylax subfasciatus* Ulmer, Gen. Insect., Fasc. 60, pl. 33, fig. 4.
1916.   *Platyphylax subfasciatus* Vorhies, Trans. Wisc. Acad. Sc., Arts and Letters, 16: 678, pl. 56, figs. 5–7.
1916.   *Allegophylax subfasciatus* Banks, Can. Ent., 48: 118, 122.
1934.   *Platyphylax subfasciatus* Betten, N. Y. State Mus. Bull., 292: 351, pl. 50, figs. 1–3.
1935.   *Stenophylax subfasciatus* Milne, St. N. Amer. Trich., 2: 52 (*lepida* listed as synonym).
1936.   *Stenophylax subfasciatus* Elkins, Ann. Ent. Soc. Amer., 29: 669, pl. I, fig. 4, pl. 5, fig. 2.
1944.   *Pycnopsyche subfasciata* Ross, Bull. Ill. State Nat. Hist. Surv., 23: 194, 195, figs. 635, 640, 675, 682 (neotype described).

The nearest allied species is *indiana* from which it differs in that the aedeagus is a little less stocky and the claspers are often narrowed more gradually to the tips. The species *subfasciata* is like *indiana* and differs from *lepida* in that the posterior margin of the eighth segment does not have a distinct mesal notch. The notch in the lateral margin of the tergite tends to be more distinctly hooked than in the two related species (figs. 91, 103).

The species has been reported from Ontario, Manitoba, Ontario, New York (July 19–Sept. 26), Massachusetts, Pennsylvania, West Virginia, Michigan, Wisconsin, Illinois, South Dakota, and Wyoming.

THE BIOLOGY OF DROSOPHILA, by M. Demerec (Editor). x+632 pages, 251 figures. John Wiley and Sons, New York. 1950. Price, $10.00.

Even our best-known insects, the house fly, the honey bee, the silk worm, and the pomace fly, are not as thoroughly known as we would like to believe. Consequently, when the present work was projected, ten years ago, it became necessary to institute research programs to fill important gaps in our knowledge of the familiar laboratory animal of the genetecists. To accomplish this, seven collaborators, Dietrich Bodenstein, Kenneth W. Cooper, G. F. Ferris, Albert Miller, D. F. Poulson, B. P. Sonnenblick, and Warren P. Spencer, were invited to prepare the work under the editorship of Dr. Demerec. The resulting volume should serve as an important reference on the fields covered, namely, the spermatogenesis, embryology, morphology and development of the postembryological stages, external and internal morphology of the adult, and methods of collecting and rearing, for *Drosophila melanogaster*. The phases of biology treated are mainly those that will interest the geneticist; but the subject matter, both in reference to this species and for comparison with other forms, will be of great interest to entomologists.—M. T. J.

NOTES ON THE PHLEBOTOMUS OF PANAMA

(Diptera, Psychodidae)

VI. PHLEBOTOMUS SHANNONI DYAR AND RELATED SPECIES[1]

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The sandflies discussed in this paper form an ill defined group mostly lacking any outstanding peculiarities. Their grouping together is for convenience and does not imply any phylogenetic significance. The males are characterized by having four major spines but no accessory setae on the style; no basal, median or apical tufts of setae on the coxite; the parameres simple, without forks, branches or modified setae; the lateral lobes relatively long and without modified spines; the aedeagus and genital filaments of conventional form, the latter from two to four times as long as the pump and with simple tips. The flared anterior end of the plunger of the sperm pump is rather small.

Females have been associated by breeding in two species and on other good evidence in two further species. In *Phlebotomus shannoni* Dyar, *P. punctigeniculatus* Floch and Abonnenc and *P. pestanai* Barretto and Coutinho, the cibarium bears four to eight horizontal teeth, the pharynx is unarmed and the spermathecae are shaped like stout sausages with short to long individual ducts joining a common duct of moderate length.

Both sexes have rather long palpi, the combined first and second segments subequal to the third, the fourth much shorter and the fifth longest. The fifth segment may or may not exceed in length the first three segments combined. The first flagellar segment of the antennae exceeds in length any palpal segment and may exceed any two segments. The ascoids are moderately long, from one-half to as long as their respective segments, except in the case of the first flagellar segment. In all those species where these structures have been described, the ascoids are biramous, bearing a proximally directed branch which may be short or exceed the base of the segment. Newstead's scales are borne on the dorsal inner aspect of the third palpal segment, being numerous and spread over the central two-thirds of the segment in those species we have examined. The second sternite is deeply divided,

though often fused apically, in the four species we have examined, being similar in all to the figures of *shannoni* given here.

Those members of the group which we have seen are conspicuously long-legged, a character of practical utility in dealing with live specimens or in sorting out lots for identification. The tibiae are particularly long compared with the femora. The ratio of tibia to femur for the hind legs ranges from 2.0 to 2.2, which was approached but not equalled by only three species in the random sampling of 25 species from other groups, in which this ratio ranged from 1.3 to 1.95.

Of described species, the following agree with the above definition in both sexes: *P. shannoni, punctigeniculatus* and *pestanai*. Males of *texanus* Dampf and *minasensis* Mangabeira can perhaps be placed here. The female of *texanus* differs in having globose spermathecae and about 19 teeth in the cibarium, while the female of *minasensis* is as

TABLE OF MEASUREMENTS IN MICRA

	shannoni 10 males		*puncti-geniculatus* 9 males		*undulatus* 5 males		*volcanensis* 8 males	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Antenna III.............	424	264	308	240	332	304	480	404
Palp I–II................	200	128	152	128	148	140	200	180
Palp III.................	156	100	128	96	116	108	176	140
Palp IV.................	76	48	96	48	68	60	84	72
Palp V..................	280	180	208	184	208	160	240	212
Wing length..............	2844	1580	2010	1740	1800	1692	2880	2610
Alpha...................	828	414	414	252	396	324	810	720
Beta....................	378	234	306	234	342	234	504	432
Gamma..................	360	162	342	216	288	198	414	270
Delta...................	216	108	90	−18	72	36	198	90

yet unrecognized. *P. maracayensis* Nunez-Tovar may have belonged in this group, but the description is inadequate and the types are no longer in existence. *P. lanei* Barretto and Coutinho, of which we have material, differs in having a somewhat elongate style, with all spines inserted well distally of the middle. The parameres are also of a different type. The proximal projections of the ascoids are very short and inconspicuous and the spermathecae are annulate.

In addition to the species discussed here, we have female specimens of two other species which may belong here. Both have long proximal branches on the ascoids, with wing and palpal measurements similar to *shannoni*. Spermathecae of one of these also have the evanescent envelope of *shannoni*, though they are differently shaped and with wholly separate ducts. The other has annulate spermathecae. We postpone their description in the hope of securing males.

Phlebotomus shannoni Dyar

(Plates I–II, figs. 1–14, Plate IV, figs. 29–30)

1929, Amer. Jour. Hyg., 10(1): 121, figs. 3–4 (♂; Cano Saddle, Gatun, Canal
Zone). Barretto 1947, Arq. Zool. S. Paulo, 5(4): 222–223.

Phlebotomus limai Fonseca 1935, Mem. Inst. Butantan, 10: 61, figs. 1–3 (♀;
Serra de Cantareira, São Paulo, Brasil).

Phlebotomus bigeniculatus Floch and Abonnenc 1941, Inst. Pasteur Guyane, Pub.
28, pp. 4–7, figs. 2–3 (♂, ♀; Cayenne, French Guiana).

Barretto (*l.c.*) has given complete references, which need not be repeated here. We have examined the types at the United States National Museum. The species has been bred in Brasil and the early stages described (Barretto 1941) so there is no question as to the association of the sexes.

We give here figures of the male genitalia, head, wing, palpi, antennae, female cibarium and spermathecae, second sternites of both sexes, together with measurements of a series of Panama specimens.

An outstanding character of the spermathecae, so far noted in only one other sandfly, the undescribed species mentioned above, is the presence of a sharply outlined, refractive envelope of uniform thickness, which can always be seen in phenol (figs. 11–12). It gives the impression of a melon cut longitudinally. The envelope may (fig. 11) or may not (fig. 12) enclose the "head" bearing the minute hairs (glandular ducts?). The envelope disappears with treatment in KOH. Tissue walls of varying thickness and degrees of visibility have also been noted in a number of other species surrounding not only the spermathecae but the ducts as well (*e.g.*, *vespertilionis*, Fairchild and Hertig 1947, Pl. I, fig. 2). In none, however, is this feature as constant and conspicuous as in *shannoni*.

The second palpal segment may bear one to three Newstead's scales on its distal end, in addition to those figured for the third segment. The pharynx, though classed as "unarmed," bears numerous very fine teeth, visible only at high magnification. This is also true of many species we have examined which do not have an obvious armature, so the term is relative.

We have examined and identified 221 males and 121 females from Panama. These were taken in 103 collections from 35 localities scattered throughout the country from sea level to 4600 feet elevation. There appears to be little seasonal variation in abundance, our material having been taken in every month of the year, ranging from four collections in October to nineteen in January. This variation probably reflects the amount of collecting done rather than the abundance of the species. The great majority of the collections (74) of this species come from crevices between the buttressed roots of forest trees, hollow trees containing bats (15) and hollow trees without bats (10). Six collections from light traps yielded this species; it has been taken twice in rock crevices and once each in an animal-baited stable trap, on an oiled paper trap on a tree trunk, and resting on a tree trunk. We have never taken it in an animal burrow, and a rather small proportion of the females have been engorged with blood. We do not know its preferred hosts. It is reported to bite man and domestic animals rarely in Sao Paulo, Brasil, in the forest, but to refuse both experimentally (Barretto 1943, Fonseca 1935, Galvao and Coutinho 1940).

Rozeboom (1944) reports it as biting man in the southern United States. In Panama we have no evidence of its biting man or, with the single exception of a specimen from a horse-baited mosquito trap, of its attacking the larger domestic animals.

In general, the species is not a dominant one, being usually outnumbered in collections from buttresses by *trinidadensis* Newst. and from bat trees by *vespertilionis* F. and H. Most of the collections consist of one or two specimens, with rarely over a dozen taken at a single place and time.

Aside from the Panama material, we have seen specimens from Georgia and Florida (reported by Rozeboom, 1944, as far north as North Carolina), six localities in Costa Rica, Colombia, French Guiana, Brasil, Paraguay and Argentina. One of us (M. H.) during intensive forest collecting in Paraguay, March to May, 1950, obtained 12 male and 8 female *shannoni* out of a total of nearly 2000 sandflies so far identified. Three females were taken on a horse or burro (not determined whether actually biting or not), the others in a Shannon light-trap, hollow trees, buttresses or on a castor-oil paper trap. The characteristic envelope of the spermathecae was noted in phenol. The seven mounted males all had the typical *shannoni* distribution of setae on the parameres. In comparisons made in the field with mounted specimens from Panama no differences could be noted.

P. abonnenci (Floch and Chassignet, 1947, Inst. Pasteur Guyane, Pub. 157, pp. 1–3, ♂) appears to us to be but a variant of *shannoni*. Among several hundreds of *shannoni* examined we have found a fair number of specimens which agree closely with Floch and Chassignet's description. In any case, almost the sole difference from *shannoni* concerns the number of setae on the dorsal surface of the parameres. In typical *shannoni* they cover the distal half (fig. 1) but vary in a continuous series to a few setae near the tip (figs. 29–30). The latter forms have always been taken in company with *shannoni*. Soon after the discovery of the second sternite as a taxonomic character, it was noted that in *shannoni* they are deeply divided but often fused apically (Hertig and Fairchild 1950, fig. 4). It was hoped that this might aid in determining whether we were dealing with more than one species. About that time we received one lot with over twenty males, about half of which had the setae limited to the tips of the parameres. There was no correlation whatsoever between the open or closed sternites and any particular distribution of the setae. We are inclined to regard our material as all *shannoni*.

Through the kindness of Dr. Floch we have been able to examine a specimen of *abonnenci* from French Guiana. It agrees in all respects with our Panama material.

Phlebotomus punctigeniculatus Floch and Abonnenc
(Plate III, figs. 15–23)

1944 (July), Inst. Pasteur Guyane, Pub. 81, pp. 5–8, fig. 3. (♂, ♀; near Cayenne, French Guiana. In crevices in trees.) Barretto 1947, Arq. Zool. S. Paulo, 5(4): p. 220.

Phlebotomus christophersoni Damasceno and Causey 1944 (October), Mem. Inst. Oswaldo Cruz, 41(2): 347–349, Pl. 4, figs. 17–21; Pl. 5, fig. 25 (♂; States of Para and Amazonas, Brasil, in hollow trees.) Barretto 1947 (l.c.), p. 193.

The shape of the paramere as figured by the above authors differs considerably, but our material shows both conditions, depending on whether the tip is flattened out or curved inwards. In balsam mounts the tip is generally curved inwards, as shown in our figure. In phenol or aqueous media the tip is generally not recurved, as shown by Floch and Abonnenc. Measurements and other structures seem to agree closely, the short delta and structure of the ascoids being especially characteristic. Floch and Abonnenc in their latest key (1947) separate *punctigeniculatus* from *christophersoni* on small differences in the relative lengths of palpal segments and genital filaments, but we do not believe these are adequate in the present case.

The proportions of the head and distribution of Newstead's scales are essentially the same as in *shannoni*. The second sternites are also substantially the same. Only two of our specimens, both males, are mounted so that the sternites can be seen well. The one figured (fig. 20) is divided and open, while the other is fused apically.

We have examined a total of 40 males and 11 females of this species from Panama and the Canal Zone. All were collected at three localities, Chorrera, Juan Mina, and Chiva Chiva. The Chorrera station was a very large hollow espavé tree (*Anacardium excelsum*) containing numerous bats, growing on the steep banks of a stream in heavy gallery forest. The exposed roots of this tree were hollow and yielded most of our specimens. A few were taken in a smaller hollow tree with bats nearby. The Juan Mina and Chiva Chiva localities were also large hollow espavé trees with bats, and although both have been visited fairly regularly, *punctigeniculatus* has been taken at Juan Mina only five times in six years, and only once at Chiva Chiva. The Chorrera station has yielded specimens eight times, on nearly every visit. Specimens have been secured in March, April, May, July, October and December.

Phlebotomus undulatus sp. nov.

(Plate IV, figs. 24–28)

Male.—Genitalia as figured. Aedeagus short, triangular. Pump and genital filaments about as long as coxite and style, the filaments 2.5 to 3 times as long as the pump, their tips not recurved. Ascoids as in *shannoni*, with long proximal prolongations. Cibarium without visible horizontal teeth, the chitinous arch distinct, apparently as in *shannoni*. Pharynx unarmed. Newstead's scales appear to be similar in number and distribution to *shannoni*, while we can not see the structure of the second sternite in any of our mounts.

Holotype male, slide no. 406, near Esquintla, Guatemala, 25 May, 1945, in buttresses of large trees along roadside. Fairchild and de Leon colls.

Paratypes, two males, same data; three males, between Esquintla and San José, Guatemala, 3 June, 1945, in buttresses and hollow trees along roadside. Fairchild and de Leon colls.

This species is very close to *shannoni*. It differs in having the internal basal spine of the style inserted on a level with or proximally to the external basal spine, instead of distally as in *shannoni*, in the

relatively long lateral lobes, and in having the setae on the paramere longer, more numerous and with a reverse curve in the middle. No females were secured. The name refers to the waved or undulant hairs of the paramere. Although this character might seem quite a trivial one, it is well marked in all our specimens, which are otherwise also quite uniform.

Phlebotomus volcanensis sp. nov.
(Plate V, figs. 31-36)

Male.—A large pale brownish species, the head and mesonotum rather dark. Genitalia as figured. Genital pump and filaments slightly longer than coxite and style, the filaments about 2.5 times as long as the pump, their tips slightly hooked. Cerci as in *shannoni*. Ascoids with long proximal prolongations, essentially as in *shannoni*. Cibarium without visible horizontal teeth, but with fairly numerous small vertical teeth. Chitinous arch well developed, its relative position similar to that of *shannoni*. Pharynx unarmed. The head proportions and the distribution of Newstead's scales also appear similar to *shannoni*, though none of our specimens show the latter well. The second sternite is mounted laterally in our series, but can be seen to be of the same type as in *shannoni*.

Holotype male, slide no. 652, and *Paratypes*, seven males, slides nos. 648, 649, 653-657, Cerro Punta, Volcán de Chiriquí, ±6500 ft. elev., Chiriquí Province, Panama, 22 to 27 May, 1946. Galindo and Fairchild colls. The specimens were taken in hollow trees and buttresses in heavy forest around Finca Carinthia. Types to be deposited in the Museum of Comparative Zoology and the United States National Museum. These were the only *Phlebotomus* seen at this locality and were distinctly rare. No females were taken.

P. volcanensis appears to belong to the *shannoni* group on the structure of genitalia and ascoids. It differs from the other species treated here in its considerably larger size and in the structure of the paramere. Further comparisons must await the discovery of the female.

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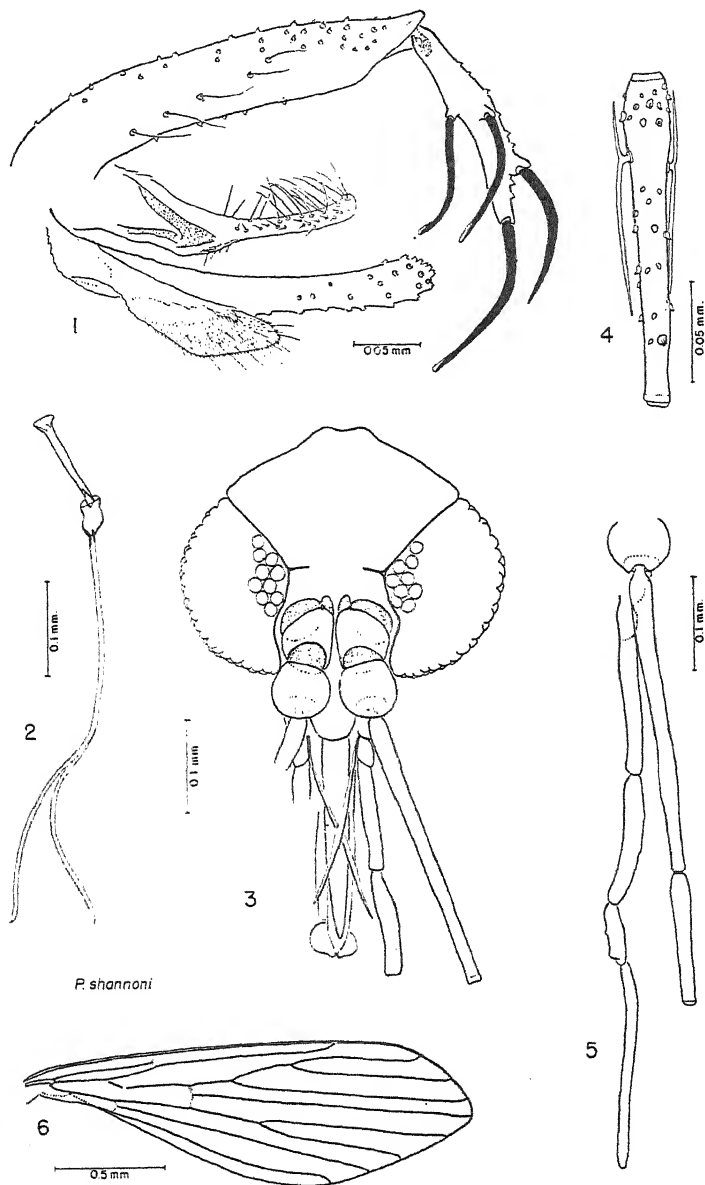
Phlebotomus shannoni. All figures are of males. FIG. 1. Male genitalia, inner aspect. FIG. 2. Genital filaments and pump. FIG. 3. Head, dorsal aspect. FIG. 4. Antennal segment IV, showing ascoids. FIG. 5. Palp and basal antennal segments. FIG. 6. Wing.

See also Plate IV, figs. 29–30, for variant form.

All figures of this and other plates were drawn by the authors with a camera lucida from balsam or copal-phenol-balsam slide mounts, unless otherwise indicated.
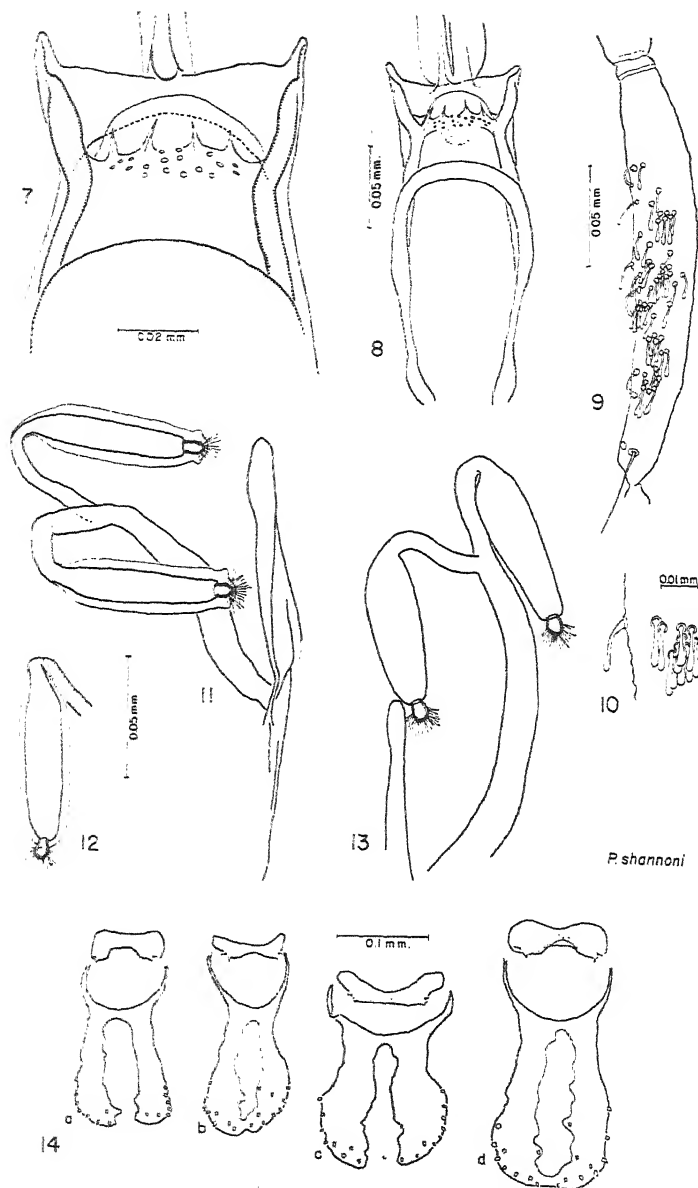
P. shannoni. All figures are from females except figs. 14-*a*, *b*. FIG. 7. Posterior end of cibarium, pigmented patch not shown. FIG. 8. Entire cibarium. FIG. 9. Third palpal segment, showing distribution of Newstead's scales. FIG. 10. A group of Newstead's scales enlarged. FIG. 11. Spermathecae, drawn in phenol before treatment with KOH to show outer envelope, which at times, as in this case, surrounds the "head." FIG. 12. Another spermatheca drawn in phenol before KOH treatment. FIG. 13. Same spermathecae as fig. 12, drawn in water after treatment with KOH. FIG. 14. First and second sternites, *a*, *b*, males; *c*, *d*, females.

P. punctigeniculatus
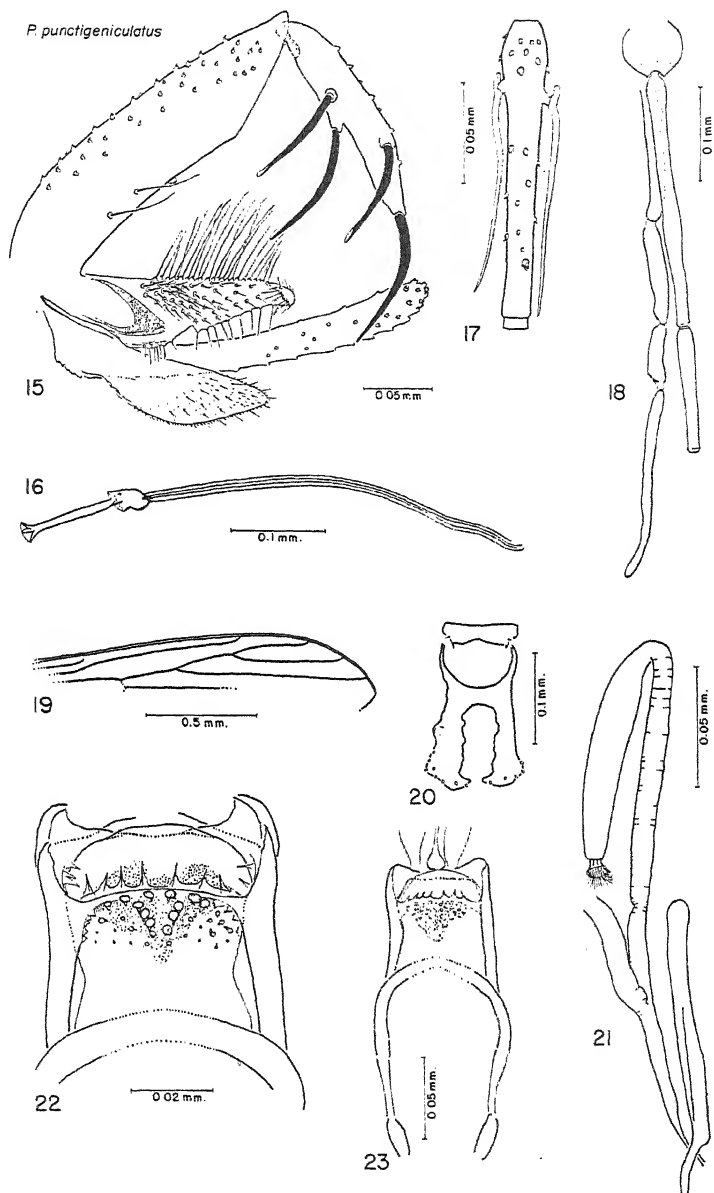
P. punctigeniculatus. Figs. 15–20, males; figs. 21–23, females. FIG. 15. Male genitalia, inner aspect. FIG. 16. Genital filaments and pump. FIG. 17. Antennal segment IV, showing ascoids. FIG. 18. Palp and basal antennal segments. FIG. 19. Wing. FIG. 20. First and second sternites. FIG. 21. Spermatheca, drawn in phenol. FIG. 22. Posterior end of cibarium. FIG. 23. Entire cibarium.
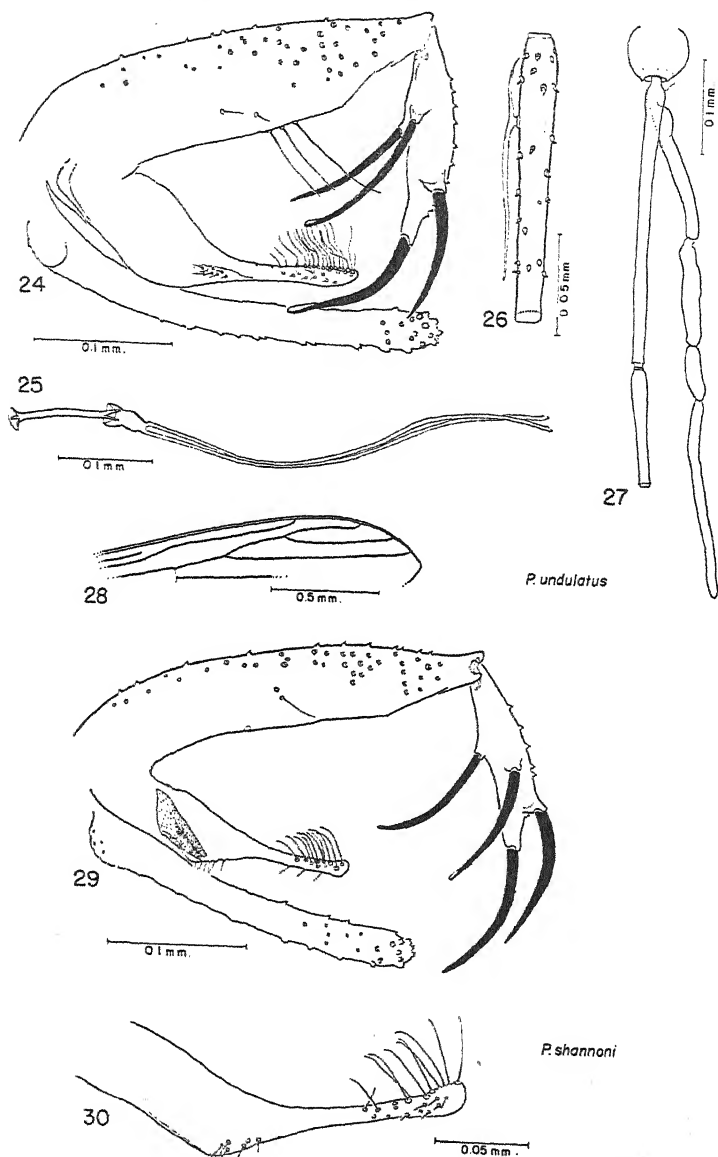
P. undulatus, sp. nov. All figures are of males. FIG. 24. Male genitalia, inner aspect, slide no. 406, holotype. FIG. 25. Genital filaments and pump. FIG. 26. Antennal segment IV, showing ascoids. FIG. 27. Palp and basal antennal segments. FIG. 28. Wing.

P. shannoni. FIG. 29. Male genitalia, inner aspect, of the form with reduced numbers of setae on the parameres. FIG. 30. Paramere of fig. 29 at greater magnification.
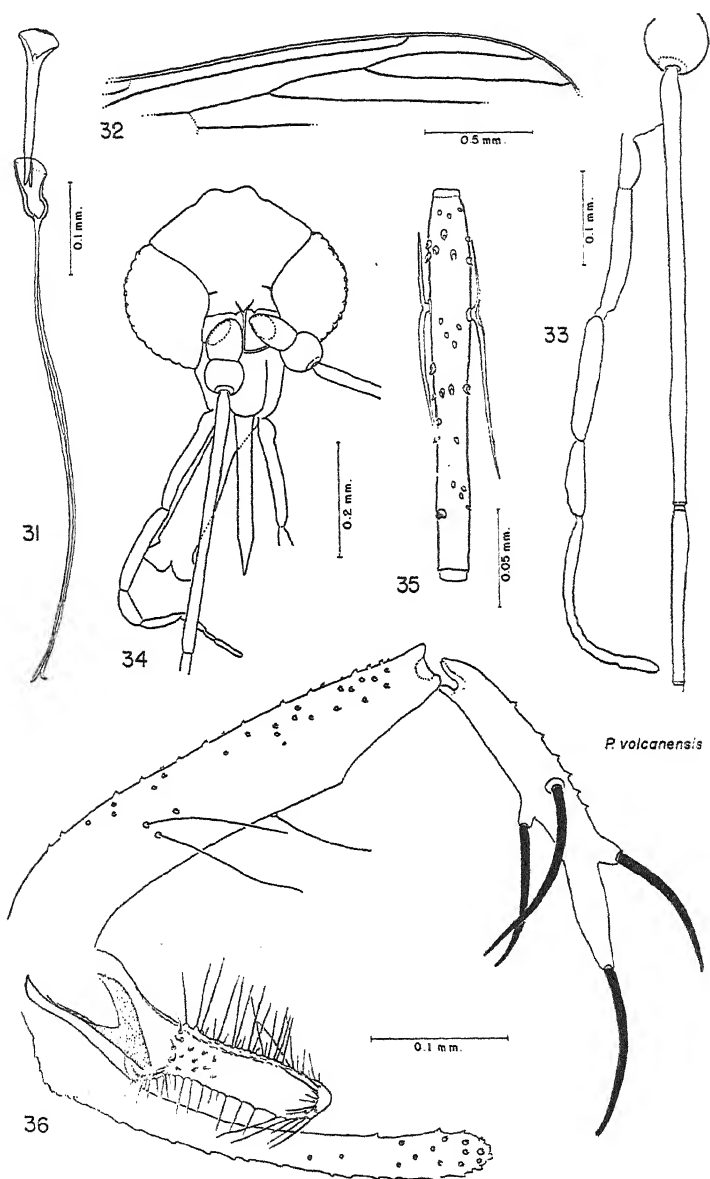
P. volcanensis, sp. nov.   All figures are of males.   FIG. 31. Genital filaments
and pump.   FIG. 32. Wing.   FIG. 33. Palp and basal antennal segments.   FIG. 34.
Head, dorsal view.   FIG. 35. Antennal segment IV, showing ascoids.   FIG. 36. Male
genitalia, inner aspect, slide no. 652, holotype.

A NEW SPECIES AND SOME RECORDS OF TRIDENCHTHONIID PSEUDOSCORPIONS

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During the past few years, the writer has received a number of collections of pseudoscorpions of the family Tridenchthoniidae (Dithidae). These collections serve as the basis for the present short report. The material examined belongs to and is deposited in four different institutions, as indicated by the following key: AMNH, American Museum of Natural History; CNHM, Chicago Natural History Museum; INHS, Illinois Natural History Survey; and USNM, United States National Museum.

Verrucaditha spinosa (Banks)

1893. *Chthonius spinosus* Banks, Canad. Ent., 25: 67.
1929. *Verrucaditha spinosa* Chamberlin, Ann. Mag. Nat. Hist., (10)4: 59.
1945. *Verrucaditha spinosa* Chamberlin and Chamberlin, Bull. Univ. Utah, 35(23): 24.

RECORDS: One female (CNHM), Evansville, Indiana, H. Dybas, June 28, 1943; one female (INHS), in fungi, Norco, Louisiana, C. L. Remington, Sept. 8, 1944; one male (INHS), at light, Chalmette, Louisiana, C. L. Remington, Oct. 15, 1944; one tritonymph (INHS), under bark, Norco, Louisiana, C. L. Remington, Nov. 3, 1944; one female, one nymph, and one male (INHS), under bark, Norco, Louisiana, C. L. Remington, Nov. 2, 1944; one female (AMNH), Sam A. Baker State Park, Missouri, C. J. Goodnight, Aug. 27, 1941. These records extend the range of this species considerably to the west, the species having previously been found in the Gulf States from Florida to Mississippi and as far north and west as Illinois.

Tridenchthonius mexicanus Chamberlin and Chamberlin

1945. *Tridenchthonius mexicanus* Chamberlin and Chamberlin, Bull. Univ. Utah, 35(23): 57.

RECORD: One female (AMNH), María Andreas, Puebla, Mexico, Goodnight and Bordas, Aug. 24, 1946.

Tridenchthonius serrulatus (Silvestri)

1918. *Chtonius* (sic!) *serrulatus* Silvestri, Boll. Lab. Zool. Gen. e Agrar., Portici, 12: 294.
1945. *Tridenchthonius serrulatus* Chamberlin and Chamberlin, Bull. Univ. Utah, 35(23): 50.

RECORDS: One male and two females (AMNH), Tafo, Gold Coast, Africa, from under bark, R. G. Donald, March 19, 1946, "B104." While the present specimens appear to have palpal podomeres that are a little larger and a little more slender than described for *T. serrulatus* by Chamberlin and Chamberlin (1945), there seems to be no doubt of the proper species determination.

Tridenchthonius addititius, new species

Because of the detailed description of the genus *Tridenchthonius* Balzan as given by Chamberlin and Chamberlin (1945), it seems unnecessary to give more than a brief diagnosis of this new species.

Male.—Description of the male is based on the holotype and one paratype. Each measurement for the paratype is given in parentheses immediately following the corresponding measurement of the holotype. Golden yellow in color; body fairly stout; condition of holotype precludes all possibility of an accurate measurement of the body length; paratype somewhat folded but probably about 1.1 or 1.2 mm. in length. Carapace subquadrate in general outline; anterior margin weakly bilobed, usually with four marginal setae on each lobe; epistome triangular in shape, margin serrate as is the medial portion of the margin of each lobe; posterior margin of carapace definitely concave and with six marginal setae; medial portion of carapace more or less free of setae, total number of setae on carapace about 80; anterior eyes much more highly developed than the posterior eyes; carapace 0.36 (0.38) mm. long, 0.45 (0.45) mm. in greatest width, posterior width of carapace 0.45 (0.44) mm., ocular width 0.37 (0.41) mm. Abdomen as usual in the genus; abdomen of neither specimen in a position suitable for observing the chaetotaxy, but sternites and tergites of middle portion of abdomen appear to have from 10 to 14 setae; abdomen of paratype probably 0.7 to 0.8 mm. long, 0.44 mm. wide.

Chelicera with eight or nine accessory setae, in general resembling closely the chelicera of *T. serrulatus* (Silvestri) as described and pictured by Chamberlin and Chamberlin (1945, fig. 12B); serrula exterior of 15 or 16 ligulate plates; chelicera 0.277 (0.26) mm. long, 0.156 (0.155) mm. wide across the base; movable finger 0.155 (0.153) mm. in length.

Palpus as usual for the genus, appearing much like that of *T. serrulatus* (Silvestri) as described by Chamberlin and Chamberlin (1945); maxilla of holotype 0.24 mm. long, 0.135 mm. wide; trochanter 0.182 (0.182) mm. long, 0.11 (0.097) mm. wide; femur 0.40 (0.405) mm. in length, 0.097 (0.103) mm. wide, length 4.1 (3.95) times the width; tibia 0.205 (0.201) mm. long, 0.10 (0.113) mm. in width; chela 0.58 (0.59) mm. long, 0.12 (0.125) mm. wide, length 4.85 (4.7) times the width; depth of chelal hand subequal to width, 0.116 (0.12) mm., length of hand 0.225 (0.23) mm.; movable finger 0.37 (0.39) mm. in length. Each chelal finger with between 45 and 50 teeth, usually a few more on the fixed finger than on the movable finger.

Legs as usual in the genus. First leg with trochanter 0.117 (0.116) mm. long, 0.093 (0.088) mm. deep; pars basalis 0.233 mm. in length in the holotype, 0.241 mm. long in the paratype, depth 0.058 (0.054) mm.; pars tibialis 0.163 (0.159) mm. long, 0.048 mm. deep in both males; tibia 0.136 (0.144) mm. long, 0.039 (0.043) mm. deep; tarsus of paratype 0.233 mm. long, 0.035 mm. deep. Fourth leg with entire femur 0.365 mm. long in both males, 0.17 (0.167) mm. deep; tibia 0.27 (0.275) mm. long, 0.078 mm. deep in both specimens; metatarsus 0.132 (0.13) mm. long, 0.05 mm. deep in both males; both holotype and paratype with telotarsus 0.26 mm. long, 0.035 (0.036) mm. in depth.

Female.—Description based on the allotype. Female very similar to the male. Body length 1.15 mm.; carapace 0.38 mm. long, 0.405 mm. wide, with ocular breadth 0.40 mm. Chelicera with movable finger 0.133 mm. long. relatively much shorter than in the male; chelicera 0.272 mm. long. 0.155 mm. wide; 15 plates in the serrula exterior. Palpus with maxilla 0.25 mm. long; trochanter 0.185 mm. long, 0.108 mm. wide; femur 0.41 mm. long, 0.105 mm. wide, length 3.9 times the width; tibia 0.233 mm. in length, 0.11 mm. in width; chela 0.61 mm. long, 0.133 mm. wide, length 4.6 times the width; chelal hand 0.225 mm. in length, 0.132 mm. in depth; movable chelal finger 0.39 mm. long. First leg with pars basalis 0.249 mm. long, 0.059 mm. deep; pars tibialis 0.156 mm. in length, 0.050 mm. deep; tibia 0.144 mm. long, 0.043 mm. deep; tarsus 0.241 mm. in length, 0.038 mm. in depth. Fourth leg with trochanter 0.195 mm. long, 0.102 mm. deep; entire femur 0.399 mm. in length, 0.156 mm. in depth; tibia 0.272 mm. long, 0.07 mm. deep; metatarsus 0.140 mm. long, 0.047 mm. deep; telotarsus 0.27 mm. in length, 0.036 mm. in depth.

Tritonymph.—With characteristics common to the tritonymphs of this group; the only data given here being the measurements of the carapace and palpus of the single available paratype. Body length about 0.86 mm.; carapace 0.37 mm. long, 0.325 mm. wide across the posterior margin, ocular breadth 0.255 mm. Palpus with trochanter 0.16 mm. long, 0.095 mm. wide; femur 0.31 mm. long, 0.082 mm. wide; tibia with length of 0.179 mm., width of 0.092 mm.; chela 0.48 mm. long, 0.101 mm. wide; chelal hand 0.195 mm. long, 0.102 mm. deep; movable chela finger 0.295 mm. long.

Type locality.—Tropical West Africa. The holotype male, the allotype female, and a paratype tritonymph (all USNM) from Mount Coffee, St. Thomas Island, Gulf of Guinea, collected during March and April, 1897; one paratype male (AMNH) taken from a log, on April 26, 1946, by R. G. Donald, at Amentia Ashanti, Gold Coast.

Remarks.—The present new species differs from other species in the genus chiefly by the size and length-width ratios of the palpal podomeres and by the chaetotaxy of the carapace. While *T. addititius* very closely resembles *T. serrulatus* (Silvestri, 1918) as redescribed by Chamberlin and Chamberlin (1945), it more nearly approximates the Mexican species with respect to the number of setae on the carapace.

Separation of *T. addititius* from the two other known African species of *Tridenchthonius* may be made by the following key:

1. Carapace with more than 100 setae 2
    Carapace with less than 80 setae . . . . **addititius**, n. sp.
2. Palpal femur with length 4.6 times the width,
                    africanus (Beier, 1931) from Mabira, Tropical East Africa
    Palpal femur with length 4.1 to 4.2 times the width,
                    serrulatus (Silvestri, 1918) from Nigeria

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STUDIES ON THE FLIGHT RANGE OF CERTAIN SIMULIIDAE, WITH THE USE OF ANILINE DYE MARKER[1]

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It is commonly accepted that certain species of flies of the family Simuliidae, namely, *Simulium (Simulium) ochraceum* Walker, *S. (S.) metallicum* Bellardi, and *S. (Lanea) callidum* Dyar and Shannon, are the most probable vectors of onchocerciasis in Guatemala and Mexico. Although to the present day this has not been experimentally proven, certain circumstances do substantiate this belief. These are: (1) The established presence of adult flies of at least one of the above species in any given part of the onchocerciasis zone; (2) The fact that these flies habitually bite humans; (3) The concurrence of greatest fly population with greatest exposure on the part of the people infected; and (4) The presence of microfilariae in dissected flies of the onchocerciasis region. (These microfilariae undoubtedly often belong to species of filariids that infect other animals.)

Although blackfly breeding is found on almost all fincas (plantations) where onchocerciasis is endemic, there are some fincas on which large populations of the adult fly are encountered but where breeding is either absent or negligible. It is this finding that stimulated the present study. For example, one such finca, Montequina (Municipality of Atitlán, Solalá, Guatemala), comprising 564 acres, is situated on the Pacific slope, southwest of the volcano Atitlán, at an altitude of 3200 feet. During the months of December and January, 1948, surveys of the blackflies breeding in the streams passing through the finca were made by the writer and no breeding was discovered. The following month the author was requested by the manager of the finca to investigate the plague of blackflies that had been biting the employees to such an extent that many were planning to seek employment elsewhere. On February 24th a visit to the finca showed that flies were in great abundance, especially in the region of the administrative buildings and the nearby dwellings. Many of the people were literally "peppered" with bites, and several had applied bandages to swollen parts of their bodies. The presence of adult flies within the buildings was the rule. In one house, as many as 100 blackflies (mainly *ochraceum*, but with small numbers of *metallicum* and *callidum*) were found resting on the muslin used as window-screening. Within the office of the finca the

flies seemed to bite as willingly as they did in the fields. This perhaps was due to the many open doors and windows which created a rather diffuse light similar to that outside the building. Comparatively few flies were found in the native huts which were constructed of mud and straw, presumably because of the extreme obscurity within. Outdoors the flies fed voraciously, always preferring situations with diffuse light; in the open sun they always chose the shaded side of the individual. The fly population on Montequina seemed in excess of that usually encountered on fincas in the onchocerciasis zone, but the habits of the flies ran true to form. A thorough survey of the streams flowing through the finca was made during the three days following, but still no breeding was found.

That part of the finca mainly affected is situated on a sharp ridge, with deep, extensive ravines on both sides. The ridge is so narrow that even a small vehicle (jeep) must back out of the area because of the lack of room for executing a turn. Because of the exposure of this ridge to winds from both the Pacific Ocean and the North, it was suspected that the simuliids had perhaps been blown into the region with squalls that had just abated. The closest fly breeding was estimated to be at least three miles from the area in question.

Spraying of all buildings, both inside and outside, with 5 percent DDT in kerosene was suggested and this, with additional spraying of the grounds in the environs, was done within a few days. Almost immediately thereafter the finca became practically blackfly-free. Long after the normal development of several generations of blackflies could have taken place the finca was still without flies. Thus it seemed quite clear that the heavy populations of flies either had been carried by winds to the finca or had migrated to it from neighboring breeding places.

It was not until February, 1949, that the entomological work of the Onchocerciasis Laboratory, situated at San Pedro Yepocapa (Chimaltenango, Guatemala), was considered far enough advanced to allow time for a flight range study. A review of the literature disclosed no records of previous flight range investigations with *Simulium*. In a few papers, mention has been made of the finding of simuliid flies at various distances from the nearest breeding places. Edwards (1) found *Simulium venustum* two miles from its probable source. However, this report was based solely on the collection of adults at a particular area rather than on the recapture of marked specimens which had been released a known distance away. Edwards also failed to mention the prevalence of the winds and the availability of blood meals in the area.

METHODS AND CONDITIONS

In the present study, made in the region of San Pedro Yepocapa, it was found impracticable to follow in their entirety the techniques usually employed. The equipment used for detecting fluorescent dyes would have been difficult to maintain in the field, and preliminary surveys would have been necessary to determine the extent to which field-caught flies were carriers of naturally occurring fluorescent particles and which these were (Reeves et al., 2). Light traps, often employed in flight range and population studies of mosquitoes, would have been

inapplicable since blackflies are normally active only from sunrise to sunset. Even if the traps had been applicable, the necessity of carrying storage batteries or generators for the operation of the traps to and from the field by foot, and the need for constant surveillance of the equipment would have precluded their use. Thus a system using simple methods and easily transportable equipment had to be devised. Since the flies to be marked and recovered were not needed for further experimental work, it was not necessary to keep them alive thereafter. Metallic dusts and aniline dyes were possibilities.

Metallic dusts[2] were tested in the laboratory with wild flies. The necessity for minute, microscopic examination of each individual fly collected, and the difficulty in preventing contamination with the dusts, made their use impractical. Aniline dyes[3] were next tested for their ability to adhere to the flies and the facility with which they could be detected with the aid of solvents.

A modification of the marking and examination techniques used by Clarke (*3*) was employed. Each dye was prepared by grinding it in a mortar with refined wheat flour[4] for one-half hour, in the proportion of one part dye to nine parts flour. The solvent was composed of three parts absolute ethyl alcohol, two parts glycerine, and one part chloroform.

Ten field-caught flies were placed in each of ten 23-ml. test tubes, which were stoppered with cotton. A minute quantity of the particular dye powder being tested was blown into the tubes by means of glass tubing with a rubber bulb. After a ten-minute settling period, the flies were transferred to large, clean glass vessels. The flies were kept segregated according to the dye with which they had been treated, and a part of each group was examined after one, two, and three days. The flies were observed under the dissecting microscope as they were placed, one at a time, in the solvent. Stained flies imparted to the solution the characteristic color of the dye. After several repetitions of this procedure, it was found that a one-minute settling period gave equally as good staining as did a ten-minute period. This method of marking gave good results, with over 90 percent of the treated flies exhibiting stain, and with no greater mortality among the stained flies than among unstained controls. Safranin Bluish was chosen for the subsequent field experiments because of the ease with which it was detected.

The experiments in the field were carried out from February 22nd to May 26th, 1949. The area chosen for the experiments covers approximately 50 square miles in the municipality of San Pedro Yepocapa, situated on the western slope of the volcanoes Acatenango and Fuego, at altitudes 2500 feet to 5500 feet (See map). The terrain is very rough, with wide and deep ravines, high cliffs, and steep

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[2]Venus Richgold Brilliant and Venus Palegold Brilliant No. 4, manufactured by the United States Bronze Powder Works, Closter, New Jersey.

[3]Carmine, Victoria Green, Safranin Bluish, Safranin O, and Methylene Blue Chloride, all made by the National Aniline Division of the Allied Chemical and Dye Corp., New York, N. Y.

[4]Chalk was first tried as a carrying agent but it seemed to cause heavy mortality of the flies.

slopes, always subject to heavy erosion by the mountain streams that rapidly pass over them. Almost all land is part of some finca, and the administrative buildings or native habitations of these gigantic plantations dot the area. There are also the small hamlets so typical of Guatemala. Approximately 20 to 35 percent of the land is cultivated to coffee, sugar cane, banana, or corn, while the rest is a dense, temperate to semi-tropical, rain forest. The area experiences two main seasons, the rainy season, usually extending from April through October, and the dry season, which extends from November through March. The flight range experiments here discussed overlapped the two seasons.

During the period February 22nd through March 31st, no rain was recorded; the average maximum and minimum temperatures for the period were 78.6° F. and 61°F., with absolute maximum and minimum temperatures of 86° F. and 55.4° F. respectively; the average relative humidity was 85, with maximum and minimum of 100 and 43. During the period April 1st through May 26th, 33.4 mm. (1.3 inches) of rain fell during 22 days; the average maximum and minimum temperatures for the period were 78.8° F. and 61.5° F., with absolute maximum and minimum temperatures of 84.2° F. and 59° F. respectively; the average relative humidity was 89, with maximum and minimum of 100 and 63. In this region, during a part of the year, October through December, the winds are extremely strong. During these months there is a complete diurnal reversal of wind direction from the north during the morning and from the south during the afternoon. When these experiments were under way, during the hours of greatest fly activity the winds constantly shifted, apparently with no definite pattern.

The municipality of Yepocapa is almost entirely within the zone of endemic onchocerciasis. The three species of flies that were used in the experiments (*S. ochraceum*, *metallicum*, and *callidum*) are all found throughout the experimental area, where there is a normal population of their hosts, both humans and domestic animals, and where breeding places of the flies are abundant. No attempt was made to use laboratory-reared flies for the flight range experiments, since it was not known to what extent laboratory rearing would affect their development and activity.

Each morning, between the hours of 8:00 a. m. and 11:00 a. m., two men made collections of wild flies at the release point, Finca La Conchita (See map). Each used the other as bait. The flies were collected by placing the mouth of a 23 ml. test tube over them as they were feeding. As soon as the tube contained 40 flies, the number of each of the three species (practically the only species biting humans in the region) was noted and the safranin-flour mixture was introduced. By using the same tube for catching and as a dusting chamber, excessive handling was avoided. After one minute, allowed for the particles to settle, the flies were released. The holding time from capture to release never exceeded 15 to 20 minutes. This procedure was continued for the entire three-hour period. During the 94-day period covered by these experiments, stained flies were released on 75 days.

Beginning on the same day as the first release of stained flies, the collection of flies was made at twenty collecting stations located at

places where larvae, pupae, and adult flies had been collected in the past. No attempt was made to use areas of maximum fly-biting or of maximum breeding. Since previous findings at the Finca Montequina and at other localities indicated that the flies travel great distances, collecting stations were established from two to eight miles from the release point. Although they were situated in all directions from La Conchita, the greater number were placed to the south, since to the north and east the terrain is much less accessible and supports a much smaller fly population. Only six collectors were available, and visits to collecting stations had to be made on foot. Since the area containing the fincas San Lucas, La Victoria, Santa Rosa, Sibaja, and Amparo was

TABLE I

COLLECTING STATIONS AND NUMBER OF TIMES EACH WAS VISITED

Finca	Distance from Release Point (miles)	No. of Times Visited	Finca	Distance from Release Point (miles)	No. of Times Visited
Niágara	2.1	57	Panajabal	4.8	61
Palo Verde	2.1	57	La Union	4.8	34
Recreo	2.6	36	Chuachilil	4.9	13
Montellano	2.7	28	Montevideo	5.1	34
Recuerdo	2.8	36	Santa Sofía	5.8	5
Queleyá	2.9	27	Sibajá	6.2	49
Santa Cristina	3.0	36	Morelia	6.3	5
Quisaché	3.0	34	La Victoria	6.3	32
Amparo	3.8	56	San Lucas	7.1	15
Guardianía Panajabal	4.4	46	Santa Rosa	7.4	50

TOTAL NUMBER OF COLLECTIONS MADE—711.

too distant to permit making the round trip, including the collection of the flies, in one day, two collectors visited this zone together and remained there over a two-day period. To all other fincas, only one collector was allotted. Even with one-man teams, it was impossible for all collecting stations to be covered every day. It will be seen in Table I how many times each station was visited during the experiments.

RESULTS AND DISCUSSION

From February 22nd to May 21st a total of 19,580 flies were stained and released, of which 9,931 were *metallicum*, 8,675 *ochraceum*, and 974 *callidum*. From February 22nd to May 26th, 711 collections were made at the twenty stations, a total of 18,707 flies being captured.[5]

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[5]It will be noted that fewer flies were collected by the six collectors than were stained by the two men at the release point. This discrepancy can be accounted for by considering: (1) that each collector usually had to collect the flies for himself, while the men staining flies were able to use each other as bait; and (2) that the number of stations visited by a collector were many, thereby limiting the time spent at any particular one, while at the release point collections were made continuously over an extended period of time.

Of this number 21 were stained flies. These included 9 *ochraceum*, 8 *metallicum*, and 4 *callidum*. They were recovered at distances ranging from 2.1 miles up to 7.4 miles from the release point. Table II shows the distances at which the flies of each species were recovered. No correlation can be made as the number of flies under consideration is much too small. Table III summarizes by periods, each containing seven days on which releases and collections of flies were made, the total number of flies of each species stained and released, the number of flies collected at the twenty stations, the number of stained flies of each species recovered, and the distance from the release point at which the latter were recaptured.

It is, of course, impossible to determine the actual distances travelled by the recaptured stained flies. Considering the extreme irregularity

TABLE II

RECOVERIES OF STAINED FLIES

FINCA	DISTANCE FROM RELEASE POINT (miles)	NUMBER OF FLIES RECOVERED		
		Simulium ochraceum	*Simulium metallicum*	*Simulium callidum*
Niágara	2.1	2	1	....
Montellano	2.7	1	1	....
Queleyá	2.9	1	1	....
Amparo	3.8	1	2	....
Guardianía Panajabal	4.4	2	....	....
Chuachilil	4.9	1	....	....
Santa Sofía	5.8	1	....	....
Recreo	2.6	....	1	....
Sibajá	6.2	....	1	....
Santa Rosa	7.4	....	1	....
Recuerdo	2.8	....	....	1
Santa Cristina	3.0	....	....	2
Montevideo	5.1	....	....	1
Totals	....	9	8	4

of the terrain, some of the ravines traversed being over 500 feet deep and over a mile wide, it is quite probable that the distances noted may be more than doubled.

It will be noted in Table III that one stained *Simulium metallicum* was recovered 3.8 miles from the release point on February 23rd, the day following the first release of stained flies. This indicates a very rapid flight and the likelihood that the flies travel great distances. Unfortunately, the regularity with which the stained flies were released and the use of only one dye preclude any further estimates of the rapidity of migration of the flies.

Because of the relatively few collecting stations in the large experimental zone, the necessity for confining them within eight miles (calculated as a straight map distance) of the release point, and the

TABLE III

Record of Stained Flies Released and Recovered

Period*	Number of Flies Released				Total Number of Flies Collected	Stained Flies Recovered		
	ochraceum	metallicum	callidum	Total		Species	Number	Distance (miles)
22–28 February	375	908	440	1723	1812	metal.	1	3.8 (23 Feb.)
1– 7 March	1324	1327	103	2754	3224	....#	....	....
8–15 March	1317	1258	90	2665	2740	metal.	1	3.8
16–23 March	1064	1275	59	2398	673	calli.	1	2.8
24–31 March	602	1550	86	2238	3166	ochra.	1	4.9
						calli.	1	3.0
1– 8 April	726	1084	59	1869	2403	ochra.	1	3.8
						ochra.	1	4.4
						metal.	1	2.6
						metal.	1	6.2
						calli.	1	3.0
9–20 April	1071	784	46	1901	873	ochra.	1	5.8
						ochra.	1	2.9
						ochra.	1	2.1
21–28 April	933	603	30	1566	1080	....#	....	....
29 April–6 May	516	466	27	1009	903	ochra.	1	2.7
						ochra.	1	4.4
7–14 May	409	430	9	848	1006	....#	....	....
16–23 May	338	246	25	609	766	ochra.	1	2.1
						calli.	1	5.1
						metal.	1	7.4
24–26 May	0	0	0	0	361	metal.	1	2.1
						metal.	1	2.7
						metal.	1	2.9
Totals	8,675	9,931	974	19,580	18,707	....	21	....

*During each period listed releases and collections were made on only seven days. The last period comprises only three days.
#No stained flies were recovered during this period.

irregularity of collections at them, it cannot be considered that the maximum range of flight has been determined. However, this was not the prime purpose of the experiment. It was desired, rather, to discover if the capacity of flight of the blackflies was such that they could migrate from a zone in which onchocerciasis is endemic to one that is supposedly free of the disease, there propagate their kind, and perhaps introduce and maintain the disease.[6] This is of extreme importance in Guatemala where the zones of onchocerciasis are considered to be rather circumscribed. Assuming that *S. ochraceum*, *metallicum*, and *callidum* are the vectors of onchocerciasis in Guatemala, the capacity of these species for making long-distance flights makes possible the extension of the disease beyond its present boundaries, should environmental conditions in neighboring areas be as suitable for fly-breeding as they appear to be.

SUMMARY

This paper presents the first published experimental data on the flight range of the Simuliidae.

The aniline dye, Safranin Bluish, has proved very efficient for marking wild-caught adult simuliids in these studies. The use of a solvent, composed of absolute alcohol, glycerine, and chloroform, greatly facilitated the recognition of the dye on recaptured flies. Details are given of the method found most satisfactory for the application of the dye.

The flight range of the blackflies was shown to be at least 7.4 miles. Because of the small number of stained flies recaptured, no attempt was made to correlate the flight capacity of the three species under consideration.

A flight of 3.8 miles in one day was recorded for one female.

The apparent similarity of environmental conditions affecting blackfly development between the onchocerciasis zones and the surrounding areas, and the great flight capacity of the probable vectors of the disease, are highly important facts to be taken into account in any consideration of the possible spread of onchocerciasis beyond its present confines.

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[6] "The Effective Flight Range" of Russell *et al.* (4).

ON DICRANOSTOMUS, A REMARKABLE PERUVIAN GENUS OF KATYDIDS; AND NOTES ON OTHER INSECTS HAVING ELONGATE MANDIBLES

(Orthoptera: Tettigoniidae)

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This report has two main objectives: First, to contribute information on the distribution and taxonomic characters of the katydid genus *Dicranostomus* Dohrn; second, to acquaint general entomologists and teachers with the principal features of these very unusual South American insects. The most conspicuous feature of these katydids is a pair of forceps-like appendages borne on the anterior surfaces of the mandibles. Most North American entomologists are scarcely acquainted with such structures except in males of the dobsonfly, *Corydalus* Latr. (Megaloptera). For this reason I have assembled brief notes on representative cases of striking mandibular structures that occur among mandibulate insects of other orders, mentioning examples that have come to my attention through the kindness of several colleagues.

Only three specimens of *Dicranostomus* are known, one of them being the male illustrated (Pl. I), which is the only example I have seen. It is from the humid forests of eastern Peru, where it was taken at Fundo Sinchono, Department of Huanuco, at an elevation of about 5,000 feet, by the professional collector Jose Schunke, August 5, 1947. Mr. Schunke, who is fully aware of the unusual nature of this insect, writes me that he has seen no other specimen in many months of collecting.

There have been two basic contributions on the genus *Dicranostomus*, Heinrich Dohrn in 1888 (Stettin Ent. Ztg. 49: 361–362, pl. 2, figs. 2a, 2b) and Brunner von Wattenwyl in 1895 (Monog. Pseudophylliden, Vienna, pp. 19, 179–180, fig. 83). Dohrn named the genus[1] and described one species, *monocerus*, based on a female from the Peruvian locality Cumbasi, near Huallaga, a District in the Department of San Martin, and about 180 miles northwest of Tingo Maria in the Huallaga Valley. In his monograph of pseudophylline katydids, Brunner indicated the position of the genus and described a second species, *nitidus*, based on a male from Peru (no detailed locality given).

The size of both of the earlier recorded specimens is essentially like the present one. The pronotum of *monocerus* was described as granulose, that of *nitidus* as smooth, the latter condition being true of my example. The female of *monocerus* had mandibular appendages approximately as long as the pronotum. In Brunner's male of *nitidus* they were nearly twice as long as the pronotum, while in mine the

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[1]The name "*Dicranostomus*" is derived from two Greek words, meaning "pitchfork" and "mouth."

appendages are slightly more than two and one-half times as long as the pronotum.   Because of our limited knowledge regarding secondary sexual characters, as well as of the characters distinguishing species in this genus, it seems advisable to identify my specimen as *Dicranostomus nitidus* Brunner.   In view of the great rarity of preserved specimens known to exist, it is hoped that the descriptive notes here furnished will be helpful to future students.   Obviously, more material is needed to show the limits of species, what variation exists, and how the sexes differ in addition to genitalic and tegminal characters.

The present specimen of *D. nitidus* is 58 mm. in overall length,[2] approximately one-third of that measurement being represented by the mandibular appendages.   Another noteworthy feature of this genus is the sharply tapering, curved horn, that arises from the front of the head, between the eyes.   Each mandible bears a single appendage on its anterior, external surface.   The appendage is broadly and strongly attached, with no suggestion of being shed at any time during the insect's life.   Except for the appendages, the mandibles are not unusual, bearing several well-formed teeth on the opposed chewing surfaces. In this respect these mandibles differ markedly from those of *Corydalus*, the latter not being used for chewing and the long forceps-like structures themselves constituting the main structures of the mandibles, not merely appendages of mandibles.   The mandibular appendages of *Dicranostomus* curve forward and are shaped as illustrated (figs. 1 and 2).[3] No trace of segmentation is evident, though each appendage has irregular transverse ripples that reflect the light.   The points are very sharp.

Nothing is known concerning the function, if any, of these appendages.   Certainly they must move considerably during the routine chewing of food, but because of the manner of attachment the apices apparently do not separate and close in the way they would if the arms swung from a single fulcrum.   Four possible functions could be suggested, but for none of them is there any evidence in this case: First, grasping the opposite sex during mating; second, defensive use when attacked; third, holding prey in the event that other insects are eaten; fourth, attacking others of the same sex at mating time.   Both sexes have at least short mandibular appendages, so the situation is not entirely comparable to that exemplified by various lucanid beetles, the males of which have specialized mandibles to use in combat whereas the females have simple mandibles.   In the complete absence of information on the habits of *Dicranostomus*, or on the nature of its food, there is just as much reason to suspect that these appendages developed as a product of orthogenesis, with no useful function at the present stage of their evolution.

Notes on habitat.—Fundo Sinchono, where the illustrated specimen was collected, was established during the recent war as an experimental cinchona plantation.   It is at an elevation of about 5,000 feet on the eastern slope of the Cordillera Azul, just over the ridge from the Huallaga Valley and about 37 miles east of Tingo Maria on the road to Pucallpa.

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[2]More formal descriptive notes are grouped near the end of this paper.

[3]I am greatly indebted to H. C. Wilcox, of the U. S. Department of Agriculture, or the photographs.

The Cordillera is the last important range of the Peruvian Andes at this latitude (about 80° 30′ S.) before reaching the lowland pampas of the Amazon basin. Rain is plentiful, about 125 inches annually, and well distributed so that rain forest is the rule. Wild species of *Cinchona* are among the dominant forest plants.[4] The specimen of *Dicranostomus* was found at the edge of a little depression in the jungle, where there was an accumulation of matted dead leaves on the ground and conditions were dark and humid.

Taxonomic notes.—*Dicranostomus* belongs to the Group Cocconoti of the subfamily Pseudophyllinae. The basic generic identification key is that of Brunner (*l. c.*), now long out of date. Lawrence Bruner (1915, Ann. Carnegie Mus. 9: 336–345) presented a key to Neotropical genera of Pseudophyllinae, closely adapted from that of Brunner. It should be noted that in the first couplet of Brunner's key (*l. c.*, pp. 9, 13) the word "mesosternum" should be substituted for "mesonotum," the latter being an error. In Brunner's diagnosis of the genus (*l. c.*, p. 179), *Dicranostomus* is said to have four spines on the hind femur, and to have a genicular spine present only on the internal lobe of the middle femur. On the other hand, Brunner's figure of *D. nitidus* plainly shows six spines on the ventral margin of the hind femur, and the same number occur in my specimen. The latter has a distinct genicular spine on the internal (or posterior) lobe of both middle and hind femora, and there is a strong possibility that the genicular spine of the hind femur was overlooked in Brunner's specimen.

In the following summary of characters noted for the Fundo Sinchono specimen, which is deposited in the U. S. National Museum, generic and specific features cannot be satisfactorily segregated in all cases; therefore, the two have been combined in view of the brief descriptions now available for both the genus and the two species.[5]

Male (Fundo Sinchono, Peru).—Head largely smooth and moderately polished; lower part of face inconspicuously, transversely wrinkled; antennae well separated; basal antennal segment unarmed, a broadly rounded elongate ridge on lower face; fastigium narrowly but strongly sulcate, the apex somewhat elevated, extending forward to about middle of antennal scrobes; a frontal spine arising between antennal scrobes, curved, tapering and acute; eyes slightly higher than long, essentially as in *Cocconotus,* mandible with strong frontal appendage as illustrated. Pronotum smooth, with sparse short pile, moderately shiny, anterior margin smooth; no trace of lateral carinae; disk of metazona directed dorsoposteriorly at about a 45° angle with disk of prozona; principal sulcus strong, extending nearly whole width of lateral lobes, prozona with much more shallow minor sulcus not extending onto lateral lobes;

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[4]My friend W. H. Hodge, of the University of Massachusetts, has kindly sent me notes on the character of this area; in fact, Dr. Hodge personally assisted in establishing the plantation. For photographs of the village of Fundo Sinchono and of representative jungle scenes nearby, as well as a discussion of the main botanical features, readers are referred to Hodge (1948, Economic Botany 2: 229–257, 34 figs.); also to "Hunting Cinchona in the Peruvian Andes," by the same author (1944, Jour. N. Y. Bot. Gard. 45: 32–43, 18 figs.).

[5]Rehn's diagnosis of *Polyancistrus* (1936, Trans. Amer. Ent. Soc. 62: 274) suggests the type of characters which usually prove to be of generic importance in this group of Orthoptera.

PLATE I
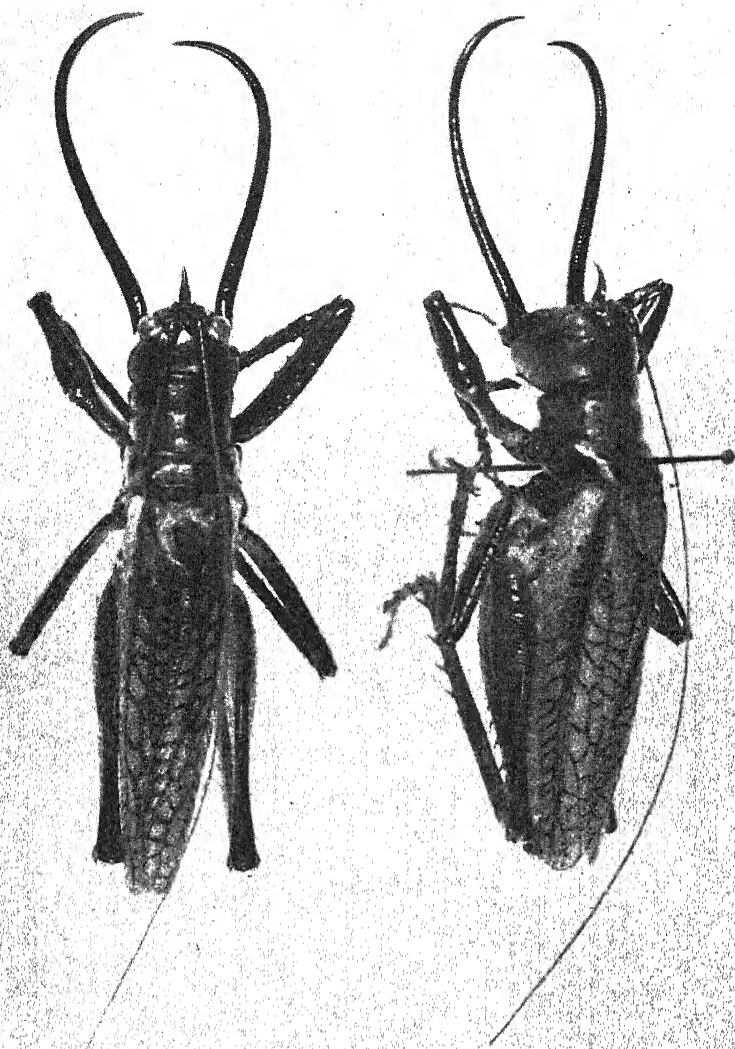
Dicranostomus nitidus Brunner, male. Fig. 1. Dorsal view. Fig. 2. Latero-dorsal view. (Length from tip of mandibular appendage to tip of wing, 58 mm.) Photograph by H. C. Wilcox.

ABBREVIATIONS

as—antennal scrobe
ce—compound eye
cer—cercus
cx_1, cx_2, cx_3—coxa of front, middle and hind leg
fe_3—femur of hind leg
fs—frontal spine
ml_2—mesosternal lobe
ml_3—metasternal lobe
msp—mesosternal pit
mt—mesal tooth of cercus

mtp—metasternal pit
sa—supra-anal plate
sg—subgenital plate
sp—prosternal spine
st_1, st_2—first and second abdominal sterna
sy—stylus
tb—tubercle of coxa
tr_1, tr_2, tr_3—trochanter of front, middle and hind leg.

PLATE II

A Remarkable Katydid
  Ashley B. Gurney
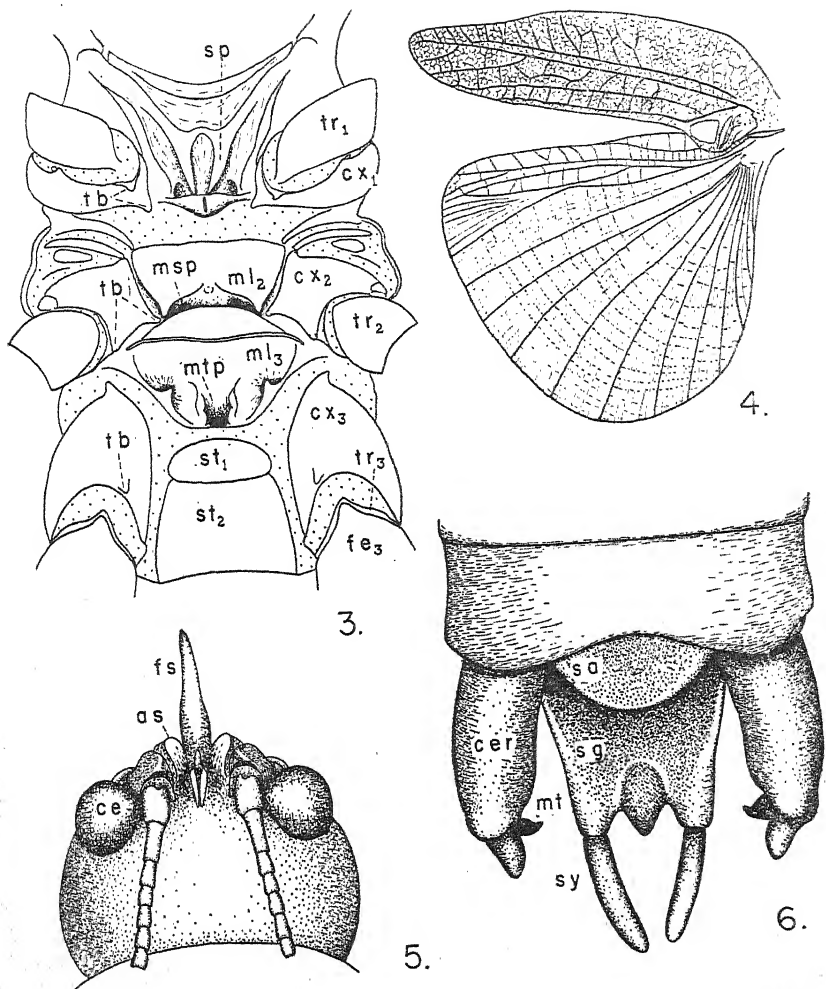
Dicranostomus nitidus Brunner, male. Fig. 3. Ventral view of thorax and base of abdomen, somewhat diagrammatic. Fig. 4. Left tegmen and wing. (Length of tegmen, 26 mm.) Fig. 5. Dorsal view of head, mandibular appendages not shown. Fig. 6. Dorsal view of apical portion of abdomen (magnification twice that of fig. 5).

(Drawings by the author)

tegmina and wings as illustrated, curving about abdomen in repose. Paired prosternal spines (fig. 3, *sp*) long, acute, extending nearly to the level of apices of front coxae; prosternal pits separated slightly more than tips of spines, a shallow longitudinal groove behind a ridge that closes pits posteriorly; mesosternal pits (*msp*) moderately separated, shallow, inconspicuous; mesosternal lobes (*ml₂*) acutely triangular, the posterior points directed sharply ventroposteriorly; metasternal pits (*mtp*) a single longitudinal, deep groove; lobes less triangularly produced than mesosternal ones, directed nearly ventrally, so that observer examining specimen in ventral view looks almost directly onto apices of lobes. Front coxae with rather long, acicular, triangular spine from anterior face (not shown in fig. 3); front and middle coxae have two blunt tubercles (*tb*) on mesal margin; hind coxae has single ventral tubercle near apex.

Front femur with four spines in apical five-eighths of ventral front margin (left femur abnormally swollen near middle, apparently due to an injury); front tibia with seven pairs of small ventral spurs, more widely spaced basally, larger apically, front dorsal margin with five low rounded tubercles; hearing organs of equal length, linear, opening dorsally, closed laterally, the lateral margins on same level with associated dorsal surface of tibia; middle femur with acute posterior genicular spine, four spines on front ventral margin; middle tibia with seven pairs of ventral spurs, dorsoposterior margin with three (left leg) or four (right leg) tiny spurs; hind femur with small posterior genicular spine, front ventral margin with six small curved spines on apical third.

Supra-anal plate broadly, evenly rounded, a ventral apical margin (not seen in fig. 6) giving a triangular appearance when seen in dorsoposterior view, a shallow median depression near base; cercus cylindrical, tapering slightly to specialized apical part, consisting of an inconspicuous dorsal swelling or "boss," a blunt arm extending ventromesally, and a dark, heavily sclerotized mesal tooth (*mt*); subgenital plate with ventral surface of disk broadly inflated, apically with a triangular median tooth; dorsally, a broad, elongate depression at base of median tooth; styli slender, cylindrical, slightly curved; all external genitalia sparsely covered with fine setae (omitted from fig 6) which in length average about the diameter of a stylus, occasional setae much longer.

Coloration: Head, thorax and legs chestnut, the tibiae darker, the mandibular appendages practically black, palpi pale; lower part of face blackish; mandibular face ventrad of appendage very reddish chestnut, teeth of chewing surface jet black; abdomen pale straw colored; tegmen with veins brown, cellules and membrane yellowish, much brighter toward base in costal area; wing with veins pale brown, membrane slightly fuscous.

Measurements (length in millimeters): Overall (tip of mandibular appendage to apex of closed wing), 58; body (base of fastigial horn to apex of cercus), 35: left mandibular appendage, 20; pronotum, 7.5; front femur, 12; front tibia, 13; hind femur, 19; hind tibia, 19; tegmen, 26. Greatest breadth of pronotum, 7.5 mm.; of tegmen, 7.5 mm.

Notes on the mandibles of other insects.—No other Orthoptera with

mandibular appendages comparable to those of *Dicranostomus* have come to my attention, though several genera have elongate mandibles. Particularly in certain South African and Australian Gryllacrididae,[6] greatly elongate mandibles occur, but in most of these examples the main body of the mandible is simply enlarged and ventrally produced, with teeth situated at the end.

Among other mandibulate insects, the elongate mandibular appendages of various beetles are probably best known, aside from the long mandibles of *Corydalus* males already mentioned. Certain Scarabaeidae and Lucanidae are especially worthy of mention. In males of the East Indian scarabaeid genus *Fruhstorferia* the cutting edge is retained near the base of the mandible, while the remainder is greatly prolonged.[7] Many genera of Lucanidae show remarkable mandibular modifications. Species of the South American genera *Chiasognathus* and *Sphenognathus* are among the most striking,[8] with one or two long tapering appendages extending forward from the mandibles of males. I have seen several species of these genera from Chile and Ecuador; so some probably live in the very region where *Dicranostomus* is found. Occasional Cerambycidae are characterized by mandibular appendages, the males of *Dendrobias virens* Casey, which occurs in the southwestern United States, being noteworthy. Long ago, Kirby (1826, Zool. Jour. 2: 70, pl. 1, fig. 7) briefly described a pair of horned mandibles, which had been found in New Zealand on a string of beads in the possession of natives. Each mandible had a long curved arm extending beyond the chewing surface. Kirby suggested that the mandibles might be those of a lucanid or cerambycid. Among the Curculionidae, the majority of broad-beaked weevils emerge from pupae with a deciduous appendage borne on the mandible. This appendage is normally shed early in adult life, leaving a scar which in some cases constitutes an important taxonomic character. These deciduous appendages are briefly discussed by Marshall (1916, Coleoptera, Curculionidae, *in* Fauna Brit. India, pp. 6–8). The male of *Ozognathus cornutus* (Lec.), an anobiid beetle inhabiting the western United States, has a single appendage borne on the anterior surface of each mandible. The appendage is usually directed upward, and it is incurved near the apex. At least one related western species of *Ozognathus* has comparable mandibular horns. But for their small size, these species would probably be better known than at present for these distinctive appendages.

The male of the African wasp, *Synagris cornuta* (L.), has a curved process from the anterior surface of each mandible, which approaches that of *Dicranostomus* as closely as that of any insect that I have seen.[9]

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[6]See Karny, 1937, Orthoptera, Gryllacrididae, *in* Gen. Insectorum, fasc. 206, pl. 1–7, and Tillyard, 1926, Insects of Australia and New Zealand, p. 96. *Hemiandrus monstrosus* of North Auckland (Stenopelmatinae), recently described by Salmon, 1950 (Dominion Mus. Records Ent., N. Z. 1(8): 175, fig. 65) has a horn-like outgrowth extending forward from the base of each mandible, apparently much like the appendages of *Dicranostomus*, though shorter.

[7]Ohaus, 1934, Gen. Insectorum, fasc. 199, pl. 3, figs. 10, 10a.

[8]Jeannel, fig. 100, *in* Traité de Zoologie, Paris, vol. 9 (Insects), 1949.

[9]See Bequaert, 1918, Vespidae of the Belgian Congo, Bull. Amer. Mus. Nat. Hist. 39: 205, pl. 2.

Several genera of ants have very elongate or sickle-shaped mandibles, but I know of none with appendages comparable to those of *Dicranostomus*. The Asiatic genus *Harpegnathus*, illustrated by Wheeler (1926, Ants, p. 17), and the New World genus *Odontomachus*, described and figured by Smith (1947, Amer. Midland Nat. 37:538), are outstanding with respect to the size and form of their mandibles. In most, if not all, species of the mayfly family Ephemeridae the nymph regularly bears a tusk on the external face of the mandible.[10]

Only a few of the more outstanding examples of specialized mandibular development are mentioned in the foregoing notes, given primarily to indicate the diversity of structures and the wide separation of including orders and families. The mandibles of males of *Corydalus* superficially resemble the mandibular appendages of *Dicranostomus* most closely, but morphologically the structures are not so comparable. Isolated genera of several orders have appendages that are largely comparable, morphologically, though the resemblance is fairly strong in only rare instances, such as the wasp, *Synagris*. In each example mentioned the structures noted probably developed entirely indedendently of those in other groups. Information on extinct and undescribed forms and the functions of their mandibles is essential for a full understanding of these specializations. Though in most groups such data are poorly known or unassembled, with their gathering a marvelous story for the evolutionist would almost surely unfold.

[10]See Needham, Traver and Hsu, 1935, The Biology of Mayflies, pp. 190, 239.

THE LEPIDOPTERISTS' SOCIETY

Word has been received from Frederick H. Rindge, Secretary, of the organization of the Lepidopterists' Society, with a constitution, by-laws, and a full set of officers. The latter include Dr. J. H. McDunnough as President, Mr. A. H. Clark as Senior Vice President, Dr. Rindge as Secretary, and Mr. J. B. Ziegler as Treasurer. The first annual meeting is scheduled at the American Museum of Natural History, New York, December 29 and 30, 1950.

STUDIES ON PROTEOLYTIC DIGESTION IN ADULT AEDES AEGYPTI MOSQUITOES[1]

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INTRODUCTION

The importance of mosquitoes in the transmission of malaria, yellow fever, dengue, encephalitis, and filariasis is well known. Since the etiological agents of all these diseases, protozoans, viruses, and nematode worms, as well as the bacteria and fungi often harbored by mosquitoes, are ingested by the insects before transmission can occur, they are obviously concerned with the digestive systems of their hosts. Extensive physiological investigations of the culicid digestive system may be expected to provide fundamental bearing on the relationships which mosquitoes have with these several disease-producing agents. Data from such research would not only add to the store of our knowledge but might conceivably be utilized in several practical ways also, such as: (a) devising a means of interrupting the development of the microorganism or virus within the mosquito, thus breaking the transmission cycle[2]; (b) repelling or destroying the mosquito itself as a result of better understanding its feeding and digestive processes[3]; or (c) assisting in the development of procedures for culturing these agents outside the mosquito.[4]

The studies reported here are confined to problems associated with the enzymatic digestion of blood by adult mosquitoes. Inasmuch as the conditions of pH, temperature, time, and state of oxidation under which an enzyme normally functions in the intact living organism are considered, as a general rule, to be close to the conditions of optimum activity for that enzyme it seemed desirable first to evaluate these factors with regard to the test species, *Aedes aegypti*. Approximate values for the average time and temperature of blood digestion in this species are available from the literature. Determinations of pH and of the apparent oxidation-reduction potential of the midgut and crop are a part of the present investigation.

Although digestive enzyme studies have been reported for a number of insects, beginning with Basch (1859) and Plateau (1875), reports on adult mosquitoes are conspicuous by their absence. DeBoissezon (1930)

[2]Whitman (1948) showed that the addition of the anti-malarial drug, M2279, to the artificial blood meal of *Aedes aegypti* at the same time, or within a few hours of the time that an infective dose of *Plasmodium gallinaceum* (bird malaria) was given, resulted in the destruction of the *Plasmodium*.

[3]DeMeillon and Goldberg (1947) have explored this possibility with the bed bug and a tick, but without success.

[4]Ball (1946) describes *in vitro* culture techniques for *Plasmodium knowlesi*.

followed the digestion of a blood meal in *Culex pipiens* by histological and histochemical methods (although no direct enzyme tests were involved) and Wigglesworth (1943) noted the complete digestion of blood, in the metabolic sense, in *Anopheles maculipennis* and *Aedes aegypti*. Metcalf (1945) was unable to demonstrate the presence of any digestive enzymes in the salivary glands of *Anopheles quadrimaculatus* although he did find a strong agglutinin and anti-coagulin in those organs. The presence of digestive enzymes in mosquito larvae was first demonstrated by Hinman (1933), who also showed that the larvae could ingest and assimilate completely dissolved nutrients from their aquatic medium.

The meagerness of data on adult mosquitoes may not be entirely fortuitous since the small size of these insects necessitates the use of large numbers per test or of greatly increasing the sensitivity and precision of the techniques employed. In the course of this investigation over 3,100 adults were dissected for examination or test.

METHODS

The yellow fever mosquito, *Aedes aegypti* (L.), was the species chosen for the experimental work because of its availability, ease of rearing and handling, and public health importance. *Anopheles quadrimaculatus* Say, the malaria mosquito[5], was also employed for certain tests, but, unless otherwise noted, all data refer to *Aedes aegypti*.

It was found that the midguts or stomachs of newly emerged adults contained a dark green mass of contaminated food debris remaining from larval life. Thirteen agar slants inoculated with midgut contents from these young adults all developed two or more types of bacterial colonies. This mass was egested during the second day following emergence so that by the third day the intestinal tract appeared to be free of bacteria or other debris. Out of 19 agar slants inoculated from 3-day-old mosquitoes, 17 developed one or more bacterial colonies, indicating that, although the midguts of the older mosquitoes appeared to be free from contamination, they were rarely so. As a result of these findings, as well as those of other workers (Bishop and Gilchrist, 1946), who found that *Aedes aegypti* females take blood most readily between the third and fifth days following emergence, mosquitoes within this age range were used exclusively. They were offered 5% sucrose on the first day, then water only, until ready for use. By the third day no food remained in the fore- and midguts and the mosquitoes are referred to as mature, unfed adults.

Hydrogen ion (pH) or oxidation-reduction (redox) potential determinations were made colorimetrically. The appropriate dyes[6, 7] were

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[5]Adults of this species were reared from eggs supplied by the Public Health Service, National Institutes of Health, Malaria Investigations Laboratory at Memphis, Tennessee.

[6]The colorimetric pH indicators used, with their respective effective pH ranges are as follows: bromphenol blue (3.0–4.6), chlorophenol red (5.1–6.7), bromcresol purple (5.2–6.8), bromthymol blue (6.5–7.5), phenol red (6.8–8.0).

[7]The oxidation-reduction indicator dyes used, with their respective standard equilibrium potentials, are as follows: sodium 2,6-dichloro-benzenone indophenol (+0.217 volts), thionine or Lauth's Violet (+0.063 volts), methylene blue (+0.011 volts).

either injected directly into the freshly dissected viscera in isolated saline droplets or they were offered in 2.5% sucrose solution on cotton pledgets to the live mosquitoes. After the dyes had been ingested, the mosquotoes were dissected to reveal the color of the ingested dye in the alimentary tract. The feeding technique avoided the difficulties of micro-injection and was preferable for unfed mosquitoes, but unsuited for bloodfed females. Approximate determinations of the midgut pH of blood-fed females were made either by injecting the dye into the blood-filled midguts isolated under oil droplets or by offering the dye mixed with fresh rabbit blood serum and noting the color of the midgut as revealed by subsequent dissection.

Analyses of the gas bubbles recovered from the crops and midguts of adult mosquitoes were made with a Berg Microanalyzer. The bubbles were collected by dissecting a series of adults in a drop of saturated lithium chloride under the flared tip of a capillary tube supported diagonally over the drop and in contact with it. After a sufficient amount of gas (0.2 cubic millimeter or more) had been accumulated, the resulting larger bubble was transferred to the microanalyzer and the gas analyzed as described by Berg (1946). Saturated lithium chloride was also used in the collecting tube and the microanalyzer because of the very low rate of diffusion of gases through that fluid.

Blood-fed females were secured by placing the bare forearm across the top of the lamp chimney in which they were confined. They were allowed only a partial blood meal before being aspirated off into individual vials in which they remained alive for one to two hours before dissection. All other materials offered as food to the mosquitoes were held in cotton pledgets placed on the top netting of the lamp chimneys. An inverted glass funnel surrounded by a cylinder of warm water was used to cover the pledget if the material was to be offered warm.

All glassware used to hold enzyme or substrate material was cleaned by soaking overnight in concentrated nitric acid, rinsed several times in tap water, then four times in distilled water and usually oven-dried. Other glassware was washed in a commercial trisodium phosphate washing powder and rinsed in tap, then distilled water. Except for the cleaning operations just described, distilled water was used wherever water is indicated.

The method of proteolytic enzyme assay developed made use of dissected-out, homogenized midguts or other organs as the enzyme material, heparinized whole rabbit blood as the subtrate, a buffer, and a preservative. Incubation was usually for six hours at 40° C. The intact midguts were dissected out from mature *Aedes* females well in advance of the experiments, accumulated into lots of 25 each, and stored in the deep freezer until needed. Just prior to an experiment they were homogenized, without abrasive, in saline to which sufficient *Merthiolate* preservative[8] had been added to give an ultimate dilution of 1 : 12,500. Two-tenths ml. portions of the resulting brei were then measured into the incubation tubes. At this point the tubes designated as blanks were placed in a boiling water bath for five minutes and then cooled.

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[8]*Merthiolate* is the brand name for sodium ethylmercurisalicylate, Eli Lilly & Co., Indianapolis, Ind.

Otherwise the blanks were handled identically with the runs. Next, 0.06 ml. of the substrate, fresh whole rabbit blood to which heparin[9] had been added to inhibit coagulation, was added to all the tubes. In determining the optimum pH of the enzyme the blood was replaced by an approximately 1% solution of serum albumin. The buffers employed were MacIlvaine's citric acid-disodium phosphate (Lange, 1946) or Michaelis' (1931) acetate-veronal buffer added in 0.1 ml. portions. The contents of the tubes were then stirred and incubation begun.

Enzyme activity was measured by increases in free amino nitrogen (incubated runs, less boiled, incubated blanks) as determined by Folin's sodium beta naphthoquinone-4-sulfonate colorimetric procedure as revised by Frame *et al.* (1943).[10] An Aminco Type F (photoelectric photometer was used to determine the optical densities of the final solutions. The technique was checked by using commercial trypsin[11] as the enzyme source.

RESULTS

A number of pH determinations on the digestive systems of insects have been published (Wigglesworth, 1938). In most cases the digestive juices are either weakly acid or weakly alkaline. However lepidopterous larvae, regardless of the type of food taken, always exhibit strongly alkaline reactions (pH 9–10). A few insect species, from other orders, in which microsymbionts or fermentation play a role in digestion show rather acid conditions, *e. g.*, termites with pH 5.2, cockroaches feeding on sugars with 4.4–4.8.

Determinations on blood-sucking insects are less numerous. Kadletz and Kusmina (1929) found an *Anopheles maculipennis* mosquito's midgut to be acid to ingested litmus while the crop was basic. MacGregor (1931) using culicine mosquitoes confirmed their results. He fed a neutral solution of sucrose and found the crop contents, after feeding, to be alkaline (approximately pH 8.5) with B. D. H. Universal Indicator. He also fed a neutral solution of bacto-peptone and found one-half hour later that the stomach was acid (approximately pH 3–4). DeBoissezon (1930) found the pH of the midgut of *Culex pipiens* to be 6–7 during digestion (his method not indicated). Lester and Lloyd (1928) working with the tsetse fly, *Glossina*, found an emulsion of midgut tissues of these insects to have a pH of 6.5. They used neutral red, a dye with an effective range of pH 6.8–8.0, so it is difficult to see how they arrived at their conclusion.

Wigglesworth (1929), also working with *Glossina*, wished to determine the pH of stomach and crop following a blood meal, but found that the color of the blood interfered with colorimetric determination. He therefore fed the flies through a membrane (vulture's skin) with either sheep serum or plasma diluted with saline. Following ingestion of either mixture he got essentially the same results. The midguts

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[9]The heparin used was "Liquaemin 100 mg./10 ml.," Roche-Organon Co., Nutley, N. J.

[10]See also Hawk, Oser, and Summerson (1947) for a description of the improved Folin technique.

[11]The commercial trypsin powder used was "Difco Trypsin 1:250," Difco Laboratories, Detroit, Mich.

averaged pH 6.6 and the crops pH 7.3. He also obtained for the more posterior sections of the midgut "where digestion was further advanced" single droplet estimations of pH 6.2 and 6.4.

The results of pH determinations made on the alimentary tracts of mature, unfed adults of both *Aedes aegypti* and *Anopheles quadrimaculatus* are given below. When the indicator dyes were offered with sucrose it was noted that the resulting pH of the crop was often slightly more acid than with the same dyes injected. The effect may have resulted from the 2.5% sucrose present, for the crops of mosquitoes fed on 5% or stronger sucrose always exhibit a definitely acid reaction (pH 5.5). The pH of the midguts as determined by either technique was the same. Although individual variations were evident, the results secured point to the following average pH values for adults without a blood meal:

Estimations of the pH of the stomach after a blood meal were made on *Aedes* females only and there with difficulty. The dye had to be observed where it was not obscured by the ingested blood. The mosquitoes were allowed to take only a small volume of blood and the

| | Crop | Midgut | | Rectum |
		Cardia	Stomach	
Aedes aegypti males or females	5.5–6.0	6.5	6.5	5.8–6.0
Anopheles quad. males or females...................	"	5.5–6.0	"	"

dissected midgut was isolated in mineral oil. Diffusion of the injected dye away from the stomach was restricted by the oil and its fate could be followed in the wall of the stomach as well as in the limited clear areas in the lumen surrounding the blood mass. With this technique the pH of the lumen appeared to be the same as that of the blood contained, i. e., about 7.3. Apparently the buffering capacity of the midgut compared to that of vertebrate blood is insignificant. It should be noted that the cells of the stomach wall remained slightly acid (pH 6.5), indicating that the buffering effect of the vertebrate blood meal was, as one would expect, limited to the lumen of the gut.

Another set of pH determinations was carried out on *Aedes* females which had been fed 1 : 1 or 2 : 1 mixtures of fresh rabbit serum and a pH indicator solution made saline with added sodium chloride. The mixtures were offered on cotton pledgets rather than through a membrane as Wigglesworth (1929) had done. The midguts of serum-fed females were definitely basic to bromcresol purple and remained so (in the living mosquitoes) for at least 3.5 hours. They were within the range of bromthymol blue. The emerald color noted for this dye in the midguts was a lighter shade (more acid) than the same dye mixed with a pH 7.0 buffer. When phenol red was employed, the rose color observed was darker (more alkaline) than the same dye at pH 7.0. The results with the latter two dyes may be interpreted to correspond to

pH values of 6.7 and 7.3, respectively.   The reason for their divergence
is not apparent.   Twenty-four hours after feeding on the serum:
bromthymol blue mixture the mosquitoes showed a color corresponding
to about pH 6.4, while those fed serum: phenol red showed approx-
imately pH 6.8.

In comparing the results just reported with those of previous workers
on related insects a lack of agreement is apparent.   Kadletz and
Kusmina (1929) and MacGregor (1931) working with mosquitoes found
the midguts to be acid and the crops alkaline.   The alkalinity of the
crops is particularly surprising, since the present writer found them to
be more acid than the midguts.   In MacGregor's experiments the crops
contained ingested sugar solutions, a situation which in the present
investigation led to increased acidity.   Wigglesworth (1928) likewise
found increased acidity in the intestines of cockroaches following the
ingestion of sugar by those insects.

The results of Wigglesworth (1929) with the tsetse fly are scarcely
comparably to those from mosquitoes.   Tsetse flies are exclusively
blood-suckers in which the crop functions simply as a storage receptacle
for blood and does not denature or digest the blood in any way.   The
pH of 7.3 for this organ reflects the pH of the serum fed, while the more
acid pH's noted for the stomach indicates that serum breakdown had
already begun.   As noted by Scheer (1948) and others the chief buffer-
ing capacity of whole blood resides in the corpuscles, so that it is pos-
sible that if whole blood, instead of serum, could have been used in the
experiments of Wigglesworth, an alkaline reaction might also have been
noted initially in the stomach of *Glossina*.

Linderstrom-Lang and Duspiva (1936) demonstrated the necessity
of a strongly negative oxidation-reduction potential in enabling the
larva of the webbing clothes moth, *Tineola biselliella*, to digest wool
fibers.   They were unable to demonstrate digestion by the isolated
midgut tissues until air was excluded and reducing substances added.
By feeding wool dyed with redox indicator dyes they established the
fact that a redox potential of –0.3 volts at pH 9.5 existed in the cater-
pillar's midgut during digestion.

Achard and Reiss (1942) have measured the redox potentials of the
body fluids of several insects and at various stages in the life cycles of
certain of them.   These authors (Reiss and Achard, 1943) believe that
the intracellular proteases of the silkworm, *Bombyx mori*, synthesize
proteins at redox potentials more positive than +0.25 volts and
hydrolyze them at less positive, or more negative, potentials.   They
found that although hydrolysis began at potentials just under +0.25
volts, it was maximum at —0.25 to —0.3 volts.   They attempted to
correlate the observed potentials in the silkworm with the type of
metabolism before and during pupation, *e. g.*, the conditions favoring
protein hydrolysis were prevalent while larval tissues were breaking
down, while the conditions of synthesis prevailed during the formation
of adult tissues.   Although the experimental data did not support
their hypothesis very strongly, they felt that the hypothesis should
not be discarded.

Feeding and injection experiments with mature, unfed *Aedes* females
using redox indicator dyes showed no evidence of reduction of any of

the dyes, except in the instance detailed below. No bleaching of the dye was observed, neither could the dye color be intensified by con- continued exposure to air or to oxidizing agents. Then sodium 2,6-dichlorobenzenone indophenol was retested with isolated midguts and crops, using a small paraffin cell from which oxygen was removed and excluded by a stream of nitrogen. Under these conditions the fluid-filled crops of dye-fed mosquitoes remained unbleached for over an hour. Because little or no dye had entered the midguts of this same batch of mosquitoes, it was necessary to inject the dye. When the injected midguts were then exposed to nitrogen the color gradually bleached until they were completely colorless in half an hour. After air was again admitted to the cell the blue color of the dye returned to full intensity within a minute. The reduction of the redox indicator by the stomach tissues under these conditions may have been occasioned by the injury to the tissues by the injection process.

TABLE I

RESULTS OF ANALYSES OF GASEOUS SAMPLES USING THE BERG MICROANALYZER

Source of Sample	Air	CO_2 (impure)	12 *Aedes*, both Sexes	15 *Aedes*, Males
Initial volume of sample in cubic millimeters..........	2.3	4.9	0.19	0.71
Percent carbon dioxide......	none	92.0	none	0.8
Percent oxygen..............	19.5	none	11.8	11.4
Percent nitrogen............	80.5	8.0	88.2	87.8

Additional information on the state of oxidation of the digestive tract was afforded by analyses of gas bubbles obtained from the crops and midguts of *Aedes* adults. According to Marshall and Staley (1932) these bubbles first appear while the mosquito is emerging from the pupa as a result of air swallowed by the adult to aid in its release from the pupal skin. The air first enters the stomach, but later is passed forward through the proventriculus to lodge in the diverticula, dorsal and ventral (the ventral diverticulum being the crop). The volume of the air bubbles may vary through the life of the mosquito and their location may alternate between the stomach and the diverticula, but Marshall and Staley found them to be absent only in hibernating females. Other authors agree as to the presence of the bubbles, but disagree as to their mode of origin or replenishment, some claiming them to be the result of anaerobic fermentation processes.

Accumulations of gas bubbles from two series of adults are listed in Table I and indicate about 88% nitrogen, 12% oxygen, and less than 1% carbon dioxide, a decrease of approximately 40% in the amount of oxygen as compared with atmospheric air. The first group of adults had not been fed for over two days, while the second group was tested more than three hours after feeding. Equilibrium conditions relative to gaseous interchange were therefore assumed to exist.

The near universal presence of gas bubbles in the mosquitoes would, by virtue of the oxygen shown to be present, establish an oxidation-reduction potential of +0.8 volts[12] in the fluid contents of crop and midgut. It should be noted, however, that these bubbles are generally more numerous in the diverticula than the stomach, especially after a blood meal when the stomach is distended with fluid. It is possible that under these conditions a greatly reduced oxygen tension may occur in the midgut, corresponding to that experimentally produced when the injected midguts were held under nitrogen.

Taken together, the results of the colorimetric tests and the analyses of the gas bubbles indicate that a negative redox potential is seldom, if ever, possible in the alimentary tract of mosquitoes and that it is evidently not essential for protein digestion, as is the case with the clothes moth larva.

The gas analyses further indicate that the gas bubbles present in mosquitoes are derived from aspirated air. The presence of oxygen and near absence of carbon dioxide in the bubbles rules out the possibility of anaerobic fermentation. The simplicity of the Berg analysis technique for very small gas samples commends it for future use in insect physiological studies, such as analyses of the contents of air sacs or large tracheae.

Determinations of the amino nitrogen content of whole mosquitoes were made at various intervals up to 24 hours following a blood meal in order to follow, if possible, changes in total amino nitrogen content as a consequence of digestion. It was anticipated that the results might approximate those from an *in vitro* enzyme test, except that the incubation of substrate with enzyme would be carried out in the living insects. The approximation would have been closer had the contents of each midgut been separated from the rest of the mosquito before analysis so that changes within the midgut might have been contrasted with shifts in amino nitrogen elsewhere in the body.

Combined results of determinations on three batches of *Aedes* females are summarized in Table II. Since the samples were weighed before the amino-nitrogen analysis it is possible to express the results in mg. amino nitrogen per gram of mosquito. It will be noted that although the freshly engorged females more than doubled their average weight in the process of feeding, the concentration of amino nitrogen in these individuals dropped to less than half. The drop was due to the amino-nitrogen concentration of the ingested rabbit blood being only about one-tenth that of the unfed mosquito's haemolymph. The diluting effect of the vertebrate blood on the concentration of amino nitrogen in the insect can be eliminated by expressing all concentrations in terms of initial body weight of the mosquito, as is done in the last column of Table II. Expressed in this manner, no increase in amino nitrogen is apparent during the first three hours following feeding, but from then on the concentration increases at an apparently uniform rate through the final determination at 24 hours.

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[12]The equilibrium potential of the theoretical oxygen electrode at one atmosphere pressure and pH 7 is close to 0.8 volts (Bull, 1943). Reducing the oxygen tension to 0.1 atmosphere (10% O_2) would depress the potential less than 0.01 volt (Clark, 1928).

Since the rate of increase in amino nitrogen has been expressed in a quantitative manner it is of interest to calculate this rate in terms of digestive activity, i. e., mg. amino acids released/mg. midgut tissues/ hour. The rate thus obtained can then be compared with the results of the enzyme tests and with the estimated enzyme activity of a hypothetical living mosquito. The rate of digestive activity is expressed per given weight of midgut tissues, since, as will be demonstrated later, these are the tissues which secrete the proteolytic enzymes. In order to do this the midguts had to be accurately weighed in the moist state or measured. The latter operation was chosen. A group of eight *Aedes* females, weighing an average of 1.2 mg. each, were dissected and their intact midguts measured with an ocular filar micrometer both as to total volume and thickness of stomach wall at various points. Cal-

TABLE II

SUMMARIZED RESULTS OF AMINO-NITROGEN DETERMINATIONS MADE ON INTACT
Aedes aegypti MOSQUITOES BEFORE AND FOLLOWING BLOOD MEALS

Type of Mosquito	Tests Included	Number of Adults	Total Wt. in mg.	Av. Wt. in mg.	Total μg. N/ Sample	mg. N/ gm. Mosq.	mg. N/ gm. Initial Wt. of Mosq.
Unfed adults....	*b, c*	30	40.8	1.4	52.0	1.3	1.3
Freshly engorged.	*a, b, c*	27	79.3	2.9	43.6	0.6	1.2
3 hours later.....	*b*	10	18.6	1.9	16.0	0.9	1.2
6 hours later.....	*a, b*	28	55.8	2.0	53.9	1.0	1.4
12 hours later.....	*b, c*	17	30.9	1.8	43.2	1.4	1.8
24 hours later.....	*c*	10	20.1	2.0	36.6	1.8	2.6

culations from these measurements gave 0.03 cubic millimeters as the average volume and 0.03 mg. as the average weight of midgut tissue per female.

The weight of amino acids released is derived from the observed increase in free amino nitrogen by assuming the protein substrate to contain 16% total nitrogen of which 80% is free amino nitrogen. On this basis the uniform rate of increase in amino nitrogen noted above corresponds to 0.0208 mg. amino acids released/mg. midgut tissue/hour.

By making several reasonable assumptions[13] it is estimated that a normal living *Aedes* female completely digests a blood meal in 72 hours, which corresponds to an average rate of 0.11 mg. amino acids released/ mg. midgut tissue/hour—considerably higher than the uniform rate of net increase in the amino nitrogen of live mosquitoes just noted.

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[13]Total hydrolysis of the blood proteins, which amount to 20% by weight of the whole blood is assumed. A full blood meal equals the weight of the unfed mosquito.

The results of the enzyme tests using blood as a substrate are summarized in Table III.   The last item in the table, commercial trypsin, was included as a check on the technique.   Except for the dissection and freezing, the trypsin preparation was carried through the same procedures as the mosquito tissues in the other tests.   When the activity of the commercial trypsin is expressed in quantitative terms it becomes 0.025 mg. amino acids released/mg. trypsin powder/hour.

Reference to Table III will show that of all the tests using blood as a subtrate only one series, the second, showed significant enzyme activity, i.e., the average net amino nitrogen recovered (run less blank)

TABLE III

SUMMARY OF ENZYME TESTS WITH FEMALE *Aedes aegypti;*
RABBIT BLOOD SUBSTRATE

Enzyme Source	Total Number of Tests	Total Number of Runs	Average Difference (runs less blanks) in μg. Amino Nitrogen	Greatest Variation within any Test in μg. Amino Nitrogen
1. Midguts dissected from unfed mosquitoes.......	7	11	+0.4	±0.7
2. Midguts from blood-fed mosquitoes............	7	13	+4.0	±0.7
3. Midguts from 5% sucrose-fed mosquitoes.........	2	8	+0.5	±0.6
4. Midguts + crops from unfed mosquitoes.......	3	6	—0.9	±0.7
5. Midguts + salivary glands from unfed mosquitoes...............	2	4	+0.9	±0.1
6. Midguts + salivary glands + crops from unfed mosquitoes.......	1	2	+0.9	±0.4
(7. 0.16 mg. commercial trypsin powder per run).	1	4	+3.1	±0.9

NOTE: Runs comprised enzyme brei plus heparinized rabbit blood as substrate plus buffer and were incubated six hours at 40° C.   Blanks used boiled enzyme brei; otherwise identical.

was greatly in excess of the maximum variation between tests.   In this series the midguts were from mosquitoes which had been allowed to take a partial blood meal before dissection.   Since the blood-fed mosquitoes used for this series were otherwise similar to those used in the first series, all of which resulted in an insignificant degree of enzyme activity, it is apparent that in *Aedes aegypti* there is an increase in the amount or activation of the proteolytic enzymes following a blood meal. Such a secretion of digestive enzymes in connection with feeding is well known among mammals where it is stimulated not only by the presence of food in the digestive tract or by the normal peristaltic muscular contractions of the tract but also by such nervous stimuli as the sight,

odor, or even thought of food.   Among insects such responses have been recorded only by Schlottke[14] (1937a, b), and, accordingly, it seemed desirable to examine the nature of this response in more detail.

Perhaps the process of feeding is in itself the necessary stimulus to protease secretion.   To determine whether the response would follow the act of feeding on a substance other than blood, adult females were allowed to feed to repletion on 5% sucrose.   In so doing they performed practically the same ingestion cycle as if they were sucking blood, except that the sucrose solution went to the crop instead of the stomach.   No increased enzyme activity in the midguts from this series was noted.

The remaining series of experiments were designed to test the hypothesis that some accessory factor necessary to stimulate the secretion of, or to activate, the protease in the midgut is produced elsewhere in the misquito and is passed into the stomach with the blood during feeding.   The hypothecated factor might be a coenzyme, a kinase, or a simple organic or inorganic activator, and it might be formed in the salivary glands or the crop.   Or the reaction might be involved in the trypsin-antitrypsin complex which Schmitz (1937) has shown exists in human blood.   In this case the "activator" might act as an inhibitor or neutralizer of the blood antitrypsin.   The method of test was simply to incubate together (with substrate) (a) midguts (from unfed mosquitoes) plus crops, (b) midguts plus salivary glands, and (c) midguts plus both crops and salivary glands.   Positive results were not secured from any of these combinations.   In fact, the combination of midguts plus crops resulted in lower recoveries of amino nitrogen from the runs than from the blanks, although the differences were not great enough to be significant.

Had positive results been secured with any of the combinations, the added organs would have been tested alone to ascertain whether or not the organ in question might be supplying the complete enzyme, rather than an aceessory factor.

Although Schlottke[14] (1937a, b) appears to be the only investigator to have reported for insects a stimulated secretion of proteolytic enzymes in response to feeding, others have reported cyclical changes in pH and in the histological picture presumed to represent secretory activity of midgut epithelium following a meal.   Schlottke worked first with other arthropods.   He failed to get a stimulatory response after feeding the horseshoe crab, *Limulus*, but with a spider he did observe some increase in activity.   His best data, however, were from insects—a predacious ground beetle, *Carabus auratus*, and an omnivorous pygmy grass-hopper, *Tettigonia cantans*.   With both insects, the sharpest increase in trypsin occurred within the first hour after feeding.   It was clearly evident in the first half hour and remained at a high level for several hours.   In the tests reported here the blood-fed mosquitoes remained alive for an hour or more after feeding.   Judging from Schlottke's data it is likely that the mosquitoes had exhibited the maximum increase in protease secretion before they were dissected.

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[14]The recent paper by Day and Powning (1949) provides additional data on the stimulation of enzyme secretions following feeding.   A hormonal, rather than neural, stimulus is favored.

Expressed on a quantitative basis the most favorable *in vitro* test with blood as the substrate—utilizing midguts from blood-fed mosquitoes—exhibited an average rate of 0.019 mg. amino acids released/mg. midgut tissue hour. In this same test only 0.34% of the available substrate in each incubation tube was hydrolyzed during the six hour incubation period. It seems clear from the amount of hydrolysis just calculated, that even 0.06 ml. of substrate per tube was in excess of that needed to stabilize the enzyme and to assure maximum opportunity for its activity. This emphasizes the importance of the midgut: substrate ratio. Whereas a large *Aedes* female will not take over two mg. of blood at a feeding, the amount of blood per midgut in the enzyme tests was usually greater than four mg. A possible situation which might account for the low rate of digestion under these conditions (of low midgut: substrate ratio) would be the interference of the mosquito protease by the trypsin-antitrypsin complex of Schmitz (1937) already referred to. If some of the mosquito protease were required to neutralize the blood antitrypsin, then the more blood present, the more *Aedes* protease would be used up in this manner.

Another factor contributing to the relative inefficiency of the *in vitro* tests is that the amount of enzyme material available for the test is limited to that initially present, less losses due to denaturation and manipulation, whereas in the living mosquito the amount of enzyme is increased or sustained by the secretion of additional amounts of enzyme from time to time.

The physical nature of the blood may also be a factor. Blood for the enzyme tests was treated with heparin to prevent coagulation during handling and a true coagulum never formed, although some settling occurred. Metcalf (1945) found ingested blood in the stomachs of *Aedes aegypti* to be coagulated, and in *Anopheles* to be agglutinated. The physical state of the blood mass in the living mosquito is therefore different than in our tests. The possible significance of this difference will be discussed later.

Preliminary experiments designed to determine the optimum pH of midgut protease were unsuccessful. When the buffered incubation mixtures were checked with a Beckman glass electrode pH Meter, Model G, it was found that the buffer then in use, Michaelis' acetate-veronal, was totally inadequate to shift the mixture more than one pH unit. This was due to the high buffering capacity of the vertebrate blood which completely eclipsed that of the Michaelis buffer at the concentrations employed. MacIlvaine's citric acid-disodium phosphate buffer at triple the recommended concentration was able to shift measured quantities of blood to the desired pH values but did not maintain the values initially secured. It was eventually decided to abandon blood as the substrate for this series in favor of serum albumin, since incubation mixtures of the latter were readily adjusted to and maintained at the desired pH values by MacIlvaine's buffer.

The results of this series are plotted in Figure 1. Reference to the figure will show that the data of the three tests, in so far as they overlap, all point to the same region of optimum activity, namely about pH 7.8, a typical value for trypsin. The observed pH optimum for the protease derived from the midguts of blood-fed *Aedes*, acting on serum albumin

substrate, is close to the normal pH of mammalian blood[15] and to that of the blood-filled midguts, but not to the pH of the midguts of unfed *Aedes* adults, which is about 6.5.

The 1% serum albumin proved to be a suitable substitute for whole blood, in fact it supported a 2.75 times higher rate of enzyme activity, 0.052 mg. amino acids released/mg. midgut tissue/hour (at pH 8), than was reached by the most favorable blood substrate test.

In view of the fact that in all insects for which a proteolytic enzyme has been experimentally confirmed, trypsin, not pepsin, has been the protease found[16], the statement of Sumner and Somers (1947) is of
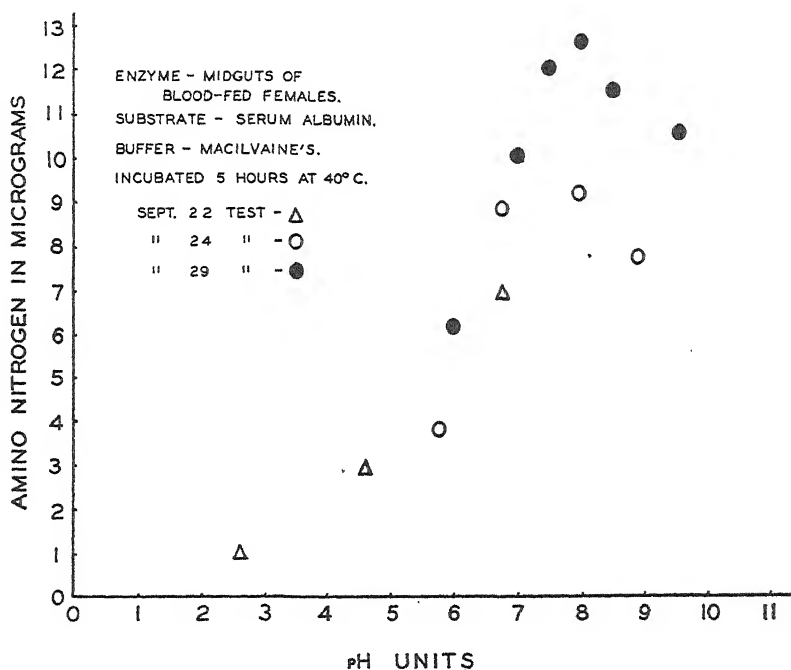
FIG. 1.   Influence of pH on the activity of *Aedes aegypti* protease.

interest: "Trypsin catalyzes the hydrolysis of peptide linkages in proteins and partly hydrolyzed proteins. Unlike pepsin, it is not an enzyme of first attack and, in several instances, it possesses only feeble action upon native proteins. It does not, for example, readily digest collagen, ovalbumin, serum globulins and hemoglobin. These proteins are readily digested by trypsin once they have been denatured by heat or any other means."

If the trypsins of insects conform to the statement above it follows

[15]Human blood has a pH of 7.3–7.4. Rabbit blood was found to be pH 7.8 with the Beckman pH Meter.

[16]Dipeptidases have also been occasionally noted (Wigglesworth, 1928), but pepsins are still unrecorded for invertebrate animals.

that the insects must either have some means of denaturing any native proteins upon which they feed or be relatively inefficient in the digestion of those proteins. In the case of mosquitoes it is possible that the coagulation or agglutination of the ingested blood serves to denature it sufficiently for digestion to begin. That the ultimate digestion of blood by mosquitoes is quite complete has already been pointed out. By contrast, some other insects, notably lice and fleas, digest blood relatively incompletely (Wigglesworth, 1943).

In mammals trypsin is not secreted in the active state, but rather as the precursor or zymogen, trypsinogen, which is converted to trypsin by enterokinase. No such zymogen: kinase relationship has been noted for insects, except the observation by Schlottke (1937a) that hog enterokinase would increase the activity of trypsin from *Carabus*. He could not locate any enterokinase in the beetle, however. Not only enterokinase, but trypsin itself, activates trypsinogen, so that an initially small amount of trypsin can cause the release of larger and larger amounts of active enzyme from a supply of the zymogen. The previously mentioned data from living *Aedes* females (in which the observed total amino nitrogen content did not increase substantially during the first three hours after a blood meal, but was followed by a uniform rate of increase from the third past the twenty-fourth hour) are suggestive of the possibility that an autocatalytic increase in trypsin from secreted trypsinogen was occurring during those first few hours.

Returning to the optimum pH determination we find that the results secured for *Aedes aegypti* agree closely with the optima secured for the tsetse fly and the cockroach by Wigglesworth (1929). Wigglesworth compared his pH curves for these two unrelated insects with the curve he secured for mammalian pancreatic trypsin. He found that the curves for the two insects could be superimposed and both were more active in the acid range (pH 5-7) than mammalian trypsin. When the date for *Aedes* are replotted in such a manner as to be compared with Wigglesworth's figure it is noted that they fall about midway between his mammalian and insectan curves so that no conclusions can be drawn from the comparison. The curve derived by Schlottke (1937a) for *Carabus* trypsin is also similar to that for *Aedes* except that he found a rather broad optimum zone between pH 8 and 9.

The similarity of the pH optima for insect trypsins is closer than the reported pH's of the midguts for the same insects. Wigglesworth found the pH of the serum-filled tsetse fly stomach to be about 6.6 and that of the cockroach on a protein diet to be 6.3. The midgut of blood-fed *Aedes*, as estimated by the writer, is about 7.3–7.8 depending on the blood contained. Yet all three of these insects have a trypsin of the same pH optimum—pH 7.8. Yonge (1937), Scheer (1948), and others have stated that the pH of the digestive organs of all animals are generally at or near the pH optima of the particular digestive enzymes involved. In this respect the *Aedes* mosquito appears to illustrate this generalization better than either of the insects tested by Wigglesworth.

It has long been known for mosquitoes that ingested blood passes directly to the stomach while other fluids, such as nectar or water, pass first to the crop and dorsal diverticula. Several hypotheses regarding this "switching mechanism" have been advanced but the fundamental nature of the mechanism remains obscure. DeBoissezon (1930) stated

that the small diameter, three microns, of the ducts leading to the crop and dorsal diverticula prevented the entrance of erythrocytes into these organs. His measurements were made on fixed tissue sections and did not take into account the flexibility of the living material. To test his contention several *Aedes* adults were offered a mixture of honey and defibrinated chicken blood,[17] which contains nucleated erythrocytes measuring about 8 by 13 microns. On subsequent dissection it was found that in all those mosquitoes which ingested the mixture both the honey and the blood, including erythrocytes, had entered the crop. Reference has already been made to the gas bubbles which are present in both midgut and diverticula and may pass from one to the others. These would not pass through openings of three microns diameter except under considerable pressure. A more plausible suggestion (Marshall and Staley, 1932) is that the relaxation of the proventricular valve or sphincter to allow blood to enter the stomach at the same time closes the openings into the three diverticula since these openings are immediately adjacent to the sphincter. This explanation does not, however, indicate the nature of the stimulus involved.

It has been suggested (MacGregor, 1931) that feeding from droplets, called "discontinuous suction," results in the crop being filled, while feeding through a membrane, called "capillary penetration," fills the midgut. Later studies (Bishop and Gilchrist, 1946) have demonstrated that it is the nature of the food, not the method of feeding, which determines its destination, *e. g.*, blood taken through a membrane or from a droplet passes to the stomach, while sugar solution taken by either method goes to the diverticula.

Feeding experiments were undertaken by the writer to discover, if possible, some relatively simple property or properties of blood which enable it to pass directly to the midgut, but the results were negative in every test. That is, the mixtures offered were found, by subsequent dissection, to have entered the crop and diverticula in greater amounts than the midgut, or were scarcely ingested at all. The blood properties simulated were: pH, temperature, peptone content, amino acid content, viscosity, osmotic pressure, and the particulate nature of the erythrocytes. They were tested singly or in certain simple conbinations, but in no case did they approach the complexity of whole blood.

SUMMARY

1. Preliminary to the proteolytic enzyme studies the pH of the alimentary canal was determined. Indicator dye solutions were either fed the adult mosquitoes or injected into the dissected-out viscera. In both sexes of *Aedes aegypti* and *Anopheles quadrimaculatus* individual variations were noted, but average values of pH 6.5 for the midgut and pH 5.5–6.0 for the crop and dorsal diverticula were secured. In *Aedes* females following a blood meal the pH of the lumen of the stomach approached that of the blood contained, *i. e.*, pH 7.3, while the crop, which contained no blood, remained acid. This shift in midgut pH is thought to be due to the high buffering capacity of the vertebrate blood.

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[17]Bishop and Gilchrist (1946) found that although whole blood, corpuscles, blood plasma and blood serum went directly to the stomach, mixtures of blood and honey passed to the crop.

When fresh rabbit serum plus indicator dye was offered to *Aedes* females the pH of the midgut was found to lie between 6.7 and 7.3 and to shift in the acid direction with time.

2. Feeding and injection experiments with oxidation-reduction indicator dyes gave no evidence of reduction except when isolated midguts were held in a cell under nitrogen gas for half an hour.

3. Microanalyses of the gas bubbles recovered from midguts and crops showed them to contain about 12% oxygen and less than 1% carbon dioxide. This confirmed published statements that they are derived from air bubbles swallowed from time to time during feeding. So long as air bubbles are present and contain oxygen the redox potential of the midgut and crop must be close to +0.8 volts. These data, together with the results just cited, support the view that a low, or negative, redox potential is neither normal nor essential for digestion in these insects.

4. Using the same amino-nitrogen determination procedure employed in the enzyme tests, the total amino-nitrogen content of whole mosquitoes was secured. No increase in amino nitrogen was noted for three hours following a blood meal, but from then on a uniform rate of increase prevailed for at least 24 hours.

5. The method of proteolytic enzyme assay devised utilized dissected-out, homogenized midguts or other organs as the enzyme material, heparinized whole rabbit blood as the substrate, and a buffer. Enzyme activity was measured by increases in free amino nitrogen determined colorimetrically.

It was found that the protease activity of midguts dissected from mature, unfed *Aedes* females was insignificant, while the activity of midguts from females permitted a partial blood meal one to two hours prior to dissection was significant. Attempts to stimulate a significant degree of enzyme activity by using midguts from sucrose-fed females, or by the addition of equal numbers of salivary glands or crops or both to the midguts from unfed mosquitoes were all unsuccessful. It is apparent that the presence of blood in the stomach stimulates proteolytic activity, but that neither the feeding syndrome in itself, nor the replete, distended abdomen, nor a mixing of precursors and activators from different regions of the digestive system, nor an enzyme origin other than the midgut is responsible for this stimulation. Nervous intermediation is conceivable but at present it can only be concluded that for unknown reasons proteolytic activity was not found except following a blood meal.[18]

6. In determining the optimum pH of the *Aedes* protease it was found preferable to use 1% serum albumin as the substrate in place of blood. A fairly sharp optimum near pH 7.8 was secured, a typical value for trypsin.

7. By making several reasonable assumptions it is estimated that a normal living *Aedes aegypti* completely digesting a full blood meal in 72 hours would do so at an average rate of 0.11 mg. amino acids released per mg. midgut tissue per hour. The maximum *in vitro* rates secured with blood and serum albumin as substrates are 17.3% and 47%, respectively, of this. The abnormal physical state of the blood and the

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[18]*See* Note 14, page 565.

reduced midgut: substrate ratio which obtained during the experiments are possibly responsible for the apparent inefficiency of the tests.

8. Feeding experiments undertaken to discover some relatively simple property or properties of blood which enable it to pass directly to the midgut while other fluids go first to the diverticula were negative. Certain of the hypotheses regarding this interesting "switching mechanism" are discussed critically.

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EXPERIMENTAL DESIGNS, by WILLIAM G. COCHRAN and GERTRUDE M. COX. ix+454 pp. London, John Wiley & Sons, Inc. Chapman & Hall, Limited. 1950. Price $5.75.

The subject of experimental designs and statistical analysis of research data has become of utmost importance in our research investigations. The authors have written the book as a manual to aid researchers in planning and evaluating their scientific investigations. References to additional statistical information for each chapter are listed.

In the first two chapters, the relationships of statistics to the experiments and to the methods of increasing accuracy are discussed. In this portion of the book experimenters are shown the value of planning their work so it can be analyzed. The analysis of field data is becoming an integral part in our investigational work and essential in presenting the results. In chapter 3 the techniques of statistics in mathematical design are outlined.

Many types of designs used in actual experimental work are explained in chapters 4 through 13. The advantages and limitations of each design are presented. Experimental designs discussed and exemplified are: complete randomization, randomized blocks, latin squares, factorials, split-plot designs, quasi-latin squares, incomplete blocks, lattices and cubic lattices, balanced incomplete blocks, lattice squares and incomplete latin squares. Plans and examples of experimental designs are copious and are one of the very desirable features of this book. In chapter 15, tables of random permutations for 9 and 16 allow for numerous random arrangements.

The treatise, although not completely suitable for workers without some knowledge in statistics, does give (pp. 1–38) an excellent and logical background of the value of statistics and how they can be used by experimenters. The authors should be commended on the presentation of experimental designs so that the book can be used as a manual by many research workers.

—LOYD L. STITT AND JOHN F. MOORE.

A QUALITATIVE ANALYSIS OF THE FREE AMINO ACIDS IN INSECT BLOOD[1]

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The free amino acid content of the blood of insects is strikingly high in comparison with that of other animals. It varies from 40 mg.% in adults and young larvae to as high as 385. mg. % in some mature larvae and in pupae (3, 5, 7, 11, 12, 13, 16, 17, 22, 29). Comparable values for the blood of decapod Crustacea are from 1.6 to 8 mg. % (23) and for whole human blood 6 mg. % (14).

Relatively little is known of the quality or quantity of the individual amino compounds which comprise this high level of amino nitrogen. Ranga-Rao and Screenivasaya (26) found 2.5% free tyrosine in the water soluble portion of the body fluids of the lac insect *Lakshadia mysorensis*. Florkin and Duchateau-Bosson (17) identified histidine and tyrosine in the blood of adults of the beetle *Dytiscus marginalis* and obtained negative tests for arginine, cysteine, cystine, phenylalanine, and tryptophane. Ussing (28, 29) recorded the first occurrence of asparagine in animal blood when he isolated this amide from the blood of larvae of *Melolontha vulgaris*. He also found arginine, histidine, leucine, lysine, tryptophane, tyrosine, valine, and probably hydroxyproline and glutamine in this species and all these except asparagine in the blood of *Oryctes nasicornis*.

Raper and Shaw (27) found alanine, glycine, leucine or isoleucine, proline, serine, tyrosine, valine, and possible arginine and lysine in the blood of nymphs of the dragon-fly, *Aeschna cyanea*. Finlayson and Hamer (15) found the above amino acids and also identified aspartic acid, histidine, isoleucine, lysine, and phenylalanine in the blood of *Calliphora erythrocephala* larvae.

EXPERIMENTAL

Amino Nitrogen Determinations

In order to obtain data concerning the quantity of blood required for amino acid analysis, the free amino nitrogen of the blood of three species was determined. Amino nitrogen was measured by the submicro method of Van Slyke, MacFadyen and Hamilton (30). An all glass apparatus was used in order to avoid the possibilities of inaccuracies due to rubber connections (30). Determinations were made on the

whole blood of larvae of *Apis mellifera* and *Galleria mellonella*, and adults of *Blatella germanica*. Aliquots of 50 microliters from pooled samples of heat-treated blood were used for all determinations. The results are presented in Table I.

Qualitative Analysis of Amino Acids

Qualitative separation and identification of the free amino acids and certain amino acid derivatives in insect blood was accomplished by the paper partition chromatographic method of Consden, Gordon and Martin (6). The technique used was essentially that described by Dent (10). All separations were carried out in two dimensions on 18 by 22.5 inch sheets of Whatman No. 1 filter paper, using phenol and a 1:1 mixture of gamma-collidine and 2, 4-lutidine as solvents. The phenol was allowed to flow over the paper for 26 to 30 hours and the collidine-lutidine for 60 hours. After revealing the positions of the amino acids by spraying the paper with a 0.1% solution of ninhydrin in

TABLE I

AMINO NITROGEN CONTENT OF THE BLOOD OF THREE
SPECIES OF INSECTS

Species	Amino Nitrogen (Mg./%)
Apis mellifera (worker larva).........	164.9
Galleria mellonella (larva)............	199.4
Blatella germanica (adult)............	56.4

n-butanol and heating in an oven at 100° C. for 10 minutes, the chromatograms were read by placing them over the diffusion plate of an X-ray illuminator (24).

Reference chromatograms were made of all of the naturally-occurring amino acids and of several other amino compounds. Methionine was revealed as its sulfoxide or sulfone and cystine as cysteic acid by oxidation of the sample with H_2O_2 as described by Dent (10). Leucine and isoleucine were not completely separable with the solvents used but definition of these compounds was obtained by a second separation in collidine-lutidine for 48 to 60 hours in a direction opposite to that of the phenol separation.

Pooled samples of whole blood were diluted with 10 times their volume of 95% ethyl alcohol (8) and the precipitated proteins removed by centrifugation. The precipitate was washed three or four times with a few microliters of alcohol in order to extract completely the free amino acids. The alcohol extract was evaporated to a volume of approximately 25 microliters by a jet of air, oxidized for methionine and cystine conversion, then placed on the filter paper for separation. Blood samples of 25, 50, 100 and, in some instances 200 microliters were analyzed for each species whenever possible.

Amino acids and other ninhydrin-reacting compounds separated from blood samples were identified by comparing blood chromatograms

with previously prepared chromatograms of pure amino acids. Positive identification of doubtful compounds was made by preparing two chromatograms from the blood sample: one of the blood alone and one to which a few micrograms of the suspected compound was added. Coincidence of the spot of the suspected compound with that of the pure compound added to the blood sample verified the identification.

In early analyses it was necessary to verify the suspected presence of glutamine and asparagine in blood samples. This was accomplished by subjecting the sample to mild hydrolysis with 6 N HCl. The absence of spots in the positions occupied by these amides on the developed chromatogram, in addition to some intensification of the glutamic and aspartic acid spots, confirmed the identification.

The free amino acids and other ninhydrin-reacting compounds identified in the blood of the seven species studied are listed in Table II.

<div align="center">DISCUSSION</div>

<div align="center">*Amino Nitrogen*</div>

The value of 164.9 mg.% of amino nitrogen in the blood of larvae of *Apis mellifera* is considerably lower than the average value of 288 mg.% reported by Bishop *et al.* (5). This difference may be attributable to normal variation in amino nitrogen content of the blood, for Ussing (29) found differences as great as 170 mg. % in the blood of *Melolontha vulgaris* larvae. Taurine also contributes to amino nitrogen measurements in some methods and may help account for the higher value of Bishop *et al.* (5) since the present study shows considerable free taurine in the blood of bee larvae.

The value of 199.4 mg.% of amino nitrogen in the blood of *Galleria mellonella* larvae agrees with published values for other lepidopterous species (3, 11, 12, 13, 22). Considerably less amino nitrogen (56.4 mg.%) was present in adults of *Blatella germanica* than was found in the larval species. Smaller quantities of amino nitrogen in the blood of adults than in that of larvae have been found in other species (13, 16, 17).

Blood extracts containing approximately 100 micrograms of amino nitrogen were found to yield chromatograms of optimum separation and definition of the amino acids present, although complete analyses could be accomplished with 50 micrograms of amino nitrogen. Approximately 200 micrograms was found to be the maximum quantity of amino nitrogen which would give clearly defined chromatograms of the amino acids in a blood sample.

<div align="center">*Free Amino Acids*</div>

In the following discussion reference will occasionally be made to the relative quantities of some of the amino acids present in the blood of certain species. Quantitative estimates are only approximate and were based on the size and intensity of the chromatographic spot and on the sensitivity data of Pratt and Auclair (24).

It is apparent from Table II that the amino nitrogen of insect blood is composed of a wide variety of amino acids and their derivatives. Alanine, glutamic acid, glutamine, glycine, isoleucine or leucine,

TABLE II

FREE AMINO ACIDS PRESENT IN THE BLOOD OF SEVEN SPECIES OF INSECTS

Amino Acid or Derivative	Blatella germanica Adult	Periplaneta americana Adult	Musca domestica Adult	Musca domestica Larva	Oncopeltus fasciatus Adult	Prodenia eridania Larva	Galleria mellonella Larva	Apis mellifera Larva Worker	Apis mellifera Larva Drone	Apis mellifera Larva Queen
Alanine	+	+	+	+	+	+	+	+	+	+
Arginine	+	-	-	+	-	+	+	+	+	+
Aspartic acid	+	-	+	+	+	+	+	+	+	+
Cystine	+	+	+	-	+	+	+	+	+	+
Glutamic acid	+	+	+	+	+	+	+	+	+	+
Glycine	+	+	+	+	+	+	+	+	+	+
Histidine	+?	-	-	-	-	+	+	-	-	+
Hydroxyproline	-	-	-	-	-	-	-	+	+	+
Isoleucine and/or Leucine	+	+	+	+	+	+	+	+	+	+
Lysine	+	+	+	+	+	+	+	+	+	+
Methionine	+	+	+	+	+	+	+	+	+	+
Phenylalanine	-	-	+	-	-	+	+	-	-	-
Proline	+	+	+	+	+	+	+	+	+	+
Serine	+	+	+	+	+	+	+	+	+	+
Threonine	+	+	+	+	+	+	+	+	+	+
Tryptophane	-	-	-	-	-	?	+	+	+	+
Tyrosine	+	+	+	+	+	+	+	+	+	+
Valine	+	+	+	+	+	+	+	+	+	+
β-Alanine	+	+	+	+	+	+	+	+	+	+
α-Amino-n-butyric acid	-	-	-	-	-	+	+	+	+	+
Asparagine	+	-	-	-	-	+	+	-	-	+
Glutamine	+	+	+	+	+	+	+	+	+	+
Taurine	-	-	+	+	+	-	-	+	+	+

+ Identified in one or more blood samples.
? Questionable identification in one or more blood samples.
− Not identified in any blood samples.

methionine, proline, serine, tyrosine, and valine were present in the blood of all species and occurred consistently in all blood samples analyzed. Occurring in smaller quantities and less consistently encountered in blood samples were α-amino-n-butyric acid, β-alanine, arginine, asparagine, aspartic acid, cystine, histidine, hydroxyproline, lysine, phenylalanine, taurine, threonine, and tryptophane. Histidine is the least sensitive of the amino acids to the ninhydrin reaction after separation on filter paper (10, 24), which may account for the failure to detect this compound in the blood of some of the species.

Histidine was not identified in blood samples of *Blatella germanica* but was found in water extracts of individual adults from which the digestive tract had been removed. Although Auclair (1) has shown that the tissues of most of the internal organs of *B. germanica* do not contain sufficient quantities of free amino acids to detect by paper partition chromatography, it is possible that the histidine may have been due to contamination by gut contents during preparation or to free histidine in tissues of the integument.

Hydroxyproline was identified only in the blood of larvae of *Apis mellifera*. The blood of queen larvae contained less than the blood of worker and drone larvae. An indication of the probable source of hydroxyproline in the blood of bee larvae is apparent in the work of Auclair and Jamieson (2) who showed that significant quantities of free hydroxyproline were present in a mixture of several species of pollen collected from a bee hive. It is generally accepted that the food of worker and drone larvae consists largely of pollen after the first two days of their feeding period, whereas queen larvae are fed solely on royal jelly. Pratt and House (25) were unable to find hydroxyproline in royal jelly, either free or as a protein constituent. Contamination of royal jelly with small quantities of pollen may explain the presence of hydroxyproline in the blood of queen bee larvae.

The spots of leucine and isoleucine coincide on two-dimensional chromatograms when phenol and collidine-lutidine are used as solvents, but partial separation occasionally occurs. Careful comparisons of chromatograms showing some separation of leucine and isoleucine with standard chromatograms indicate that both of these compounds are probably present in all the species studied. Positive identification of leucine and isoleucine in the blood of larvae of *Prodenia eridania* and *Galleria mellonella* was accomplished by separation in three directions, as described above. Finlayson and Hamer (15) recently identified both leucine and isoleucine in the blood of *Calliphora erythrocephala* larvae by two-dimensional chromatography using phenol and benzyl alcohol as solvents.

The presence in insect blood of certain amino acids other than those which are known protein constituents is of interest to studies on the metabolism of nitrogenous compounds by insects.

β-Alanine, which was found in the blood of all species except adults of *Periplaneta americana* and larvae of *Musca domestica*, occurs in vertebrate tissues in combination with histidine in the peptides carnosine and anserine (4) but these compounds are not known to be present in invertebrate tissues (21). Dent (10) detected β-alanine in plant tissues, thus indicating that it is available to animals in their food. Auclair (1)

found that *l*-cystine is responsible, directly or indirectly, for the formation of β-alanine in *Blatella germanica*. Since β-alanine is a constituent of pantothenic acid, which is required by some insect species for growth (18, 19, 20), it may arise as a metabolic product of this vitamin.

α-Amino-n-butyric acid was identified in the blood of larvae of *Prodenia eridania, Galleria mellonella*, and queen larvae of *Apis mellifera*. Dent (8, 9) has shown that this amino acid is present in human blood and urine and can be formed metabolically from methionine. Auclair (1) found that *Blatella germanica* can also metabolize methionine to α-amino-n-butyric acid.

The presence of asparagine in the blood of four of the species studied is especially interesting, for it had not been detected in the blood or tissues of animals until recently when Ussing (28, 29) isolated the compound from the blood of *Melolontha vulgaris* larvae. Insects apparently obtain asparagine from plants where it occurs widely and parallels the function of glutamine in animal blood by serving as a storage compound for ammonia (4).

Glutamine was present in the blood of all species studied. It is an important metabolite in both plants and animals, where it functions in ammonia storage and metabolism. Ussing (29) has pointed out that glutamine may function in uric acid synthesis in insects since it has been demonstrated that the rate of uric acid formation by bird liver slices increases upon the addition of glutamine.

Taurine was found in relatively large quantities in the blood of *Musca domestica* larvae and adults, *Apis mellifera* larvae, and *Oncopeltus fasciatus* adults. High concentrations of taurine have been found in muscle tissue of certain invertebrates and smaller quantities are present in vertebrate muscle (4), but the presence of this compound in insect blood or tissues has not previously been reported. Dent (10) identified taurine in human blood and urine. The function of taurine as a constituent of vertebrate bile salts is well known but its function as a free compound in animal tissues is unknown (4). A study of the metabolism of taurine by insects might reveal information concerning their bile function.

The ability of insects, particularly during the larval stage, to store large quantities of free amino acids in the blood invites speculation as to the purposes and mechanisms of such storage. Amino nitrogen studies on holometabolous insects by other workers indicate that blood amino acids increase in quantity as the larva grows (12), remain high during pupation (7, 17, 22), then decrease somewhat in the adult (7, 11, 17). It is of interest that the amino nitrogen content of pupae is little, if any, greater than that of the blood of mature larvae (5, 7, 13, 17). These observations substantiate the suggestion of Ussing (29) that amino acids stored by the larva may be used for protein synthesis during metamorphosis. Deaminating enzymes must be absent or inactive to account for the progressive increase of amino nitrogen during larval development and for its maintenance at a high level during pupation. It is not known whether there are any quantitative changes in the amino nitrogen content of the blood of adults with aging or in the blood of hemimetabolous insects during development.

SUMMARY

1. The free amino nitrogen content of the blood of three species of insects was determined and the following quantities found: *Apis mellifera* larvae, 164.9 mg.%; *Galleria mellonella* larvae, 199.4 mg.%; *Blatella germanica* adults, 56.4 mg.%.

2. The free amino acids present in the blood of seven species of insects were analyzed qualitatively by means of paper partition chromatography. The amino acids and deivatives found present in the blood of all the species were: alanine, glutamic acid, glutamine, glycine, leucine or isoleucine, methionine, proline, serine, tyrosine, and valine. Those found present in only certain of the species were: β-alanine, α-amino-n-butyric acid, arginine, aspartic acid, asparagine, cystine, histidine, hydroxyproline, lysine, phenylalanine, taurine, threonine, and tryptophane.

.3. The possible sources and metabolic significance of some of the amino acids found in insect blood are discussed.

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ERRATUM

The passage on page 406, third paragraph, lines 8 and 9, beginning with the word "*Phlebotomus*," should read: "*Phlebotomus* was found on eight occasions and at all elevations. A total of 176 . . ." instead of "*Phlebotomus* was found at thirteen localities in six different parishes at elevations." The latter passage occurs in the previous paragraph, lines 3 and 4, in its correct context.

NOTES ON THE FORM OF DISTRIBUTION OF INSECT AND PLANT POPULATIONS

F. M. WADLEY

PROBLEMS INVOLVED

Many population studies result in figures of number of organisms per unit, as per square foot or per plant. The frequency distributions involved are of interest, for what they can tell us of the tendencies of the organisms concerned, and for light they shed on proper statistical analysis.

It is easy to show that if a population distributes itself over a number of units at random, the distribution of numbers per unit will approximate a Poisson series. Deviation from a Poisson will indicate failure of randomness. Experience shows that there is nearly always a departure from the Poisson, in the direction of greater dispersion and higher variance. There is an excess of zeros and high values over Poisson expectation. This indicates unequal probability among units of receiving organisms. Sparse populations often come near the Poisson; denser ones usually diverge more from it. Variance is equal to the mean in the Poisson; comparison of variance and mean is a test for divergence.

Some mathematical distributions have been fitted with allowance for the divergence. If one distribution is consistently successful, it may be supposed to give a mathematical picture of the divergence. Fisher (1941) has recently called attention to the negative binomial of the form $(q-p)^{-k}$, where $q = 1+p$, and k is positive. Neyman (1939) and Beall (1940) have fitted contagious distributions involving a compounding of simple random tendencies. Fracker and Brischle (1944) advanced the idea that a mixture of Poisson and contagious distributions might explain some natural distributions.

A suitable transformation for analysis of population values may be suggested by the distribution (see Cochran 1938, Beall 1942). The square root transformation is suited for Poisson data; the logarithm of $(n+1)$ is better for the divergent distributions usually found. Beall (*l.c.*) has tabled a transformation suited to the degree of divergence found, passing from the square root toward the logarithmic. In some cases a special transformation may be derived from a specific problem. The proper transformation will give a distribution nearer the normal and will stabilize variance.

However, in many cases in practice, the total number of organisms per set of units, or per experimental treatment, is sufficient to give an approach to normal in successive samples. All these distributions tend to approach the normal as numbers increase. For this reason, and because analytical procedures give fairly good results in slightly skew distributions, transformations may be dispensed with in many cases.

These distributions have been fitted to a number of population counts. In some cases the figures are from uniformity counts in solid

areas; in others, from sample counts scattered over their areas. In either case, counts will reflect the distribution tendencies.

METHODS USED

The first cases studied are of organisms of Ribes bushes in forest; this is the material studied by Fracker and Brischle (*l.c.*). In a typical case, 80 units of 1/10 acre each are enumerated, with results as follows:

Bushes per unit	0	1	2	3	4	5	above 5
Frequency	43	15	8	6	3	4	1

In the "above 5" class was one area with 13 bushes. There were 94 bushes on the 80 areas, with mean 1.18 and variance 3.89.

The Poisson series, standard of randomness, can easily be fitted. The general term for proportion of units with a given number, X, is: $\dfrac{e^{-\overline{x}} \cdot \overline{X}^x}{X!}$

(Here $\overline{X}$ is the mean and X! is "factorial X"). In fact, the terms of a Poisson have been tabled by Pearson (1930, Table 51) for various means at intervals of 0.1. In the above case, the expected Poisson frequencies for a mean of 1.18 are about 24, 29, 17, 7, 2, and 1, respectively, for values of 0, 1, 2, 3, 4, 5. There is plainly a wide discrepancy; the variance 3.89, greatly exceeding the mean, 1.18, is enough to indicate this.

Neyman's "Contagious distribution" in its simpler form (Type A, 2 parameters) is next fitted. The expected proportion of units with zero is first calculated; successive terms are then figured from the preceding ones. The relation of the mean $(\overline{X})$ and variance (V) is used to calculate constants; $m_1 = \overline{X}^2/(V - \overline{X})$: $m_2 = (V - \overline{X})/\overline{X}$. The expression for proportion of zeros is: $P_o = e^{-m_1} (1 - e^{-m_2})$. The general expression for terms other than zero is:

$$P_{(n+1)} = \left[(m_1 \cdot m_2 \cdot e^{-m_2})/(n+1) \right] \cdot S^n_{k=0} \left[m_2^k/k! \cdot P_{(n-k)} \right]$$

For the case cited above, with V=3.89 and $\overline{X}$=1.18:

$m_1 = (1.18)^2/(3.89 - 1.18) = 0.514$

$m_2 = (3.89 - 1.18)/1.18 = 2.297$

e^{-m_2} = antilog $(-m_2 \times \log e)$ = antilog (-2.297×0.4343) = antilog (-0.9976) = 0.1006

$1 - e^{-m_2} = 0.8994$

$-m_1 (1 - e^{-m_2}) = (-0.514 \times 0.8994) = -0.4623$

$e^{-m_1} (1 - e^{-m_2}) = e^{-0.4263}$ = antilog (-0.4623×0.4343) = antilog (-0.2008) = 0.6298

Since P_o =0.63 about, the expected number (F_o) is 80 x 0.63 or 50.4.

For P_1 we have: $\left[(m_1 \cdot m_2 \cdot e^{-m_2})/1 \right]$. $\left[(m^o_2/0!) P_o \right]$

  0! is factorial 0, equal to 1)

    or $\left[(0.514 \times 2.297 \times 0.1006)/ \right]$ x 1/1) (0.63)=0.0748

  F_1 is 80 x 0.0748 or 6.0

For P_2 the expression is $\left[(m_1 m_2 e^{-m_2})/2 \right] \left[(m^o_2/0!) (P_1) + m^1_2/1! \right) (P_o) \right]$ which gives us 0.0902; F_2 is estimated as 7.2

For P_3 we have: $\left[(m_1 m_2 e^{-m_2})/3 \right] \left[(m_2^o/0!) (P_2) + m_2^1/1! \right) (P_1) + (m_2/2!) (P_o) \right]$ This is solved as 0.0760, with F_3=6.1

Succeeding frequencies are solved in the same way as 4.2, 2.6 and 3.5; for 4, 5 and all above 5 respectively. The last figure is secured by subtraction.

The negative binomial has the general term:

$P^x = q^{-k} \cdot [(k+X-1)!/X!(k-1)!] \cdot (p/q)^x;$

Where k is $\overline{X}{}^2/(V-\overline{X})$, and p is $(V-\overline{X})/\overline{X}$ (the same as m_1 and m_2 of the contagious distribution) and $q = 1+P$.

In the present example $k = 0.514$, $p = 2.297$, $q = 3.297$.

For P_0 the expression reduces to q^{-k}, or

$P_0 = 3.297^{-0.514} = $ antilog $(-0.514 \times \log 3.297) = $ antilog $('-0.2663) = 0.542$

$F_0 = 80 \times P_0 = 43.4$

$P_1 = 0.542 [0.514!/(1!-0.486)!] (2.297/3.297)^1.$

To solve this, $(0.514)!$ and $(-0.486)!$, must be secured from a table of factorials such as Pearson's (*l.c.*, Table 31). When this is done, the expression becomes:

$0.542 \times 0.887/1.726 \times 0.6967 = 0.1941$, and

$F_1 = 0.1941 \times 80$, or 15.5,

$P_2 = 0.542 [1.514!/2 (-0.486)!] (0.6957)^2 = 0.1023$, and

$F_2 = 8.2$.

In the same way, frequencies for 3, 4, 5 and above 5 are estimated as 4.8, 2.9, 1.8 and 3.4 respectively.

The three distributions fitted can now be compared with actual frequencies.

TABLE I

DISTRIBUTION	UNITS HAVING							CHI-SQUARE
	0	1	2	3	4	5	6 and up	
Poisson.......	24.6	29.0	17.0	6.7	2.0	0.5	0.2	35.8** (3)
Contagious....	50.4	6.0	7.2	6.1	4.2	2.6	3.5	17.6** (4)
Negative binomial....	43.4	15.5	8.2	4.8	2.9	1.8	3.4	4.7 (4)
Actual........	43	15	8	6	3	4	1	....

Chi-square for the Poisson is computed by lumping small classes to give an expected frequency over 1 in the smallest class. This leaves 5 classes (24.6, 29.0, 17.0, 6.7, 2.7). A degree of freedom is deducted for the mean and one for the total number, leaving 3 degrees of freedom. Chi-square is computed as $S[(O-C)^2/C]$, where C is the calculated and O the observed number in each class. The other two distributions have 7 classes, all with expected frequencies over 1; but 3 deductions must be made, for mean, variance and total number, since both mean and variance are used in fitting.

The number of degrees of freedom follows each chi-square in parenthesis. An asterisk indicates significance at the 5% point, 2 asterisks show significance beyond the 1% point. The high chi-square for the Poisson shows marked divergence of the actual counts from Poisson theory. The chi-square for the contagious distribution is lower but still significant. Other forms of the contagious distribution might be tried, but Beall (*l.c.*) shows that all give rather similar results.

The chi-square for the negative binomial is low, well in line with expectation, and shows that the sample could easily be from a distribution of this sort.

RESULTS WITH SEVERAL POPULATION COUNTS

The methods outlined have been tried on several other *Ribes* counts, on some counts of wireworm larvae in soil secured through the kindness of E. W. Jones (see Jones 1937), and on two Japanese beetle larval counts. The results are shown in Tables II, III, and IV. For each analysis is shown the total number, mean, variance, and chi-squares for the Poisson, contagious and negative binomial distributions.

Results of the *Ribes* counts are shown in Table II. They are for tenth-acre units unless otherwise specified. The counts are from solid areas, and in some cases were of remaining or new bushes some time after a cleanup operation. Variances are relatively high and the

TABLE II

RIBES DISTRIBUTION COMPARED WITH THEORY

AREA	N	$\overline{X}$	V	CHI-SQUARE FOR		
				Poisson	Contagious	Negative Binomial
Kaniksu........	80	1.18	3.89	35.8** (3)	17.6** (4)	4.7 (4)
Cow Creek.....	100	2.96	19.80	265.7** (7)	410.4** (6)	11.9 (6)
Mt. Spokane...	64	1.22	12.30	52.1** (3)	539.3** (1)	8.1* (2)
Clearwater.....	64	1.52	8.92	77.2** (4)	165.1** (4)	0.3 (4)
Beaver Creek.	400	1.06	3.05	251.4** (4)	35.8** (3)	1.0 (3)
" " (sq. rds.)....	6,400	0.0662	0.1004	237.0** (1)	14.0** (2)	0.6 (3)

counts give a severe test to distributions. The Beaver Creek data were also available by square rods, as shown. Because of the large numbers these would be expected to show high chi-squares, but the fit of both compound distributions was fair or good. This data was also available by acres, with n=40, $\overline{X}$=10.60, V=74.72. It showed a broad, flat distribution, impossible to fit reasonably by Poisson or contagious, but preliminary trials showed the negative binomial as giving promise of a fair fit.

The wireworm distributions are from sample units scattered over their area. Units were $\frac{1}{4}$ to $\frac{1}{16}$ square foot. Variance is not high in most cases. In a few cases of low mean and variance, distributions were not calculated, since they were close to Poisson expectation, and classes were too few to test the other distributions. This omission applied to all cases with means below 0.50, and one with mean 0.89.

Lastly, two distributions of Japanese beetle larvae in soil were fitted. The counts are of larvae per square foot, in solid areas, and were from the material described by Fleming and Baker (1936). The two

sparser populations were used. The higher populations showed distributions approaching symmetry, and offered considerable difficulty in arithmetic because of the number of terms.

It is easy for divergence from any distribution to appear, because of the large numbers involved. In one case Fisher's suggestion of using the maximum likelihood fitting was explored for the negative binomial. It offered only a small improvement.

TABLE III

WIREWORM DISTRIBUTIONS COMPARED WITH THEORY

N	$\overline{X}$	V	CHI-SQUARE FOR		
			Poisson	Contagious	Negative Binomial
100	0.77	1.17	10.6* (3)	5.2* (1)	4.4 (2)
100	0.90	1.30	10.4* (3)	9.2* (3)	6.7* (2)
100	1.94	3.31	32.0** (5)	2.4 (4)	2.5 (4)
101	2.64	15.73	140.8** (6)	509.2** (6)	15.6 (9)
100	0.50	1.10	14.3** (2)	2.6 (2)	1.6 (3)
100	0.64	0.98	3.9 (2)	2.5 (2)	1.1 (2)
100	0.73	0.78	4.5 (2)	5.6 (1)	2.8 (1)
100	0.83	1.76	15.5** (2)	6.2 (3)	0.8 (4)
100	0.88	1.10	4.7 (3)	0.4 (2)	0.2 (2)
100	1.13	1.97	15.6** (3)	9.9* (4)	5.5 (4)
99	2.05	5.96	30.1** (5)	17.9* (7)	6.9 (7)
198	2.83	7.54	162.1** (7)	14.2 (8)	3.8 (9)

TABLE IV

JAPANESE BEETLE GRUB POPULATIONS COMPARED WITH THEORY

N	$\overline{X}$	V	CHI-SQUARE FOR		
			Poisson	Contagious	Negative Binomial
2500	2.76	5.88	781.3** (7)	149.6** (10)	62.8** (10)
2500	5.14	12.27	3100.5** (14)	94.2** (15)	36.8** (15)

DISCUSSION AND CONCLUSION

First it may be noted that the negative binomial as used was practically always better than the Poisson or the form used of the contagious distribution. The latter was usually, but not always, better than the Poisson. Furthermore, the distributions usually did not show significant departure from the negative binomial, and usually did show significant departures from the other two.

Next the distributions may be divided into those showing little excess of variance over mean, moderate excess, and great excess. Where variance was not over 150% of the mean, the Poisson might give a

fairly satisfactory fit. With variance from $1\frac{1}{2}$ to 3 times the mean, the contagious distribution and the negative binomial both surpassed the Poisson, and the advantage of the latter over the former was not great. In the several extreme cases, with variance 6 to 10 times the mean, the contagious distribution was even worse than the Poisson, and the negative binomial still gave a fairly good fit.

As previously stated m_1 (or k) is calculated as $\overline{X}^2/(V-\overline{X})$, m_2 (or p) as $(V-\overline{X})/\overline{X}$. Where the variance greatly exceeds the mean, m_2 or p is large, and m_1 or k is moderate in size. Where the variance approaches the mean, k becomes large and p small. With variance equaling the mean (Poisson condition), p will be zero. In long series it may be seen that each frequency of the negative binomial is fitted as the product of a constant term, a middle term first increasing and then decreasing, and a third term decreasing as a power of a fraction. With the contagious distribution each frequency is fitted as the product of a decreasing first term, and a compound term first increasing, then decreasing.

In the cases where the negative binomial is markedly better than the contagious distribution, the superiority of fit has usually been in the first few terms; zeros, ones, twos, etc. The negative binomial expression for zero frequency is evidently a better representation of actual conditions than that of the contagious distribution. (Compare q^{-k}, or in Neyman's notation $(1+m_2)^{-m_1}$ with Neyman's $e^{-m_1}(1-e^{-m_2})$).

It seems likely that the negative binomial will give in general a better representation of actual population distributions than the contagious distribution. This may be tentatively connected with the assumptions involved. In both the parameter used for the simple Poisson is assumed to vary. The "contagious" assumes discontinuous variation of this parameter. The negative binomial assumes continuous variation of the type shown by Eulerian curves. The latter assumption seems to fit bitter the factors governing population distributions.

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LIST OF THE APHIDIDAE OF THE MALAY PENINSULA, WITH DESCRIPTIONS OF NEW SPECIES
(HOMOPTERA)

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The aphid fauna of the Malay Peninsula has not been thoroughly explored and about 17 species of these insects have been recorded from the Peninsula, including Singapore, by van der Goot, Corbett, Takahashi and others. In this paper a list is given of 68 species and subspecies now known to occur on the Peninsula, of which 15 are described as new to science.

All the specimens were collected by the author unless otherwise stated and all of them, including the types, were deposited in the Selangor Museum, Kuala Lumpur.

The author is much indebted to Messrs. Y. Takeda and K. Takeda, through whose aid he has been enabled to continue entomological work in Japan. Thanks are also due to Dr. Y. Okada, Mr. Y. Asanuma and Mr. M. Moritsu for their kind help in various ways.

Cervaphis cambodiensis Takahashi

Host plant, *Grewia tomentosa*; attacking the lower side of young leaf.

Kuala Lumpur: very common, sometimes occurring in large numbers, but no alate form was detected.

Hitherto known from Cambodia, French Indo-China (Govt. Agr. Res. Inst. Formosa, Rept. No. 78, p. 9, 1941).

Setaphis viridis van der Goot

Host plant, *Glochidion* sp.; attacking the young branch.

Kuala Lumpur (31.XII.1942). Previously recorded from Johore (Philippine Jl. Sc., 21: 422, 1922).

Neophyllaphis podocarpi Takahashi

Host plants, *Podocarpus* spp., attacking the young leaf.

Kuala Lumpur: apterous forms (20.VII.1943; 22.VII.1944); Rampang, the Riouw Islands (I.1946).

Paratrichosiphum roepkei van der Goot

Host plant, *Euyra sp.?*

Singapore (Tijdschr.v.Ent., 60: 115, 1918). Not collected by the author.

Greenidea anonae Pergande

Host plant, *Baccaurea motleyana ?* attacking the lower side of young leaf.

Kuala Lumpur: many apterous forms and a few nymphs of alate form attended by *Oecophylla smaragdina* (18.IV.1943).

Greenidea ficicola Takahashi

Host plant, *Ficus* sp.; attacking the lower side of leaf.

Cameron Highlands (5000 ft.): many apterous forms (24.IX.1944).

Body mostly brownish black on the dorsum, shining; head yellowish brown; cornicles blackish brown, darker apically. The specimens differ from the Formosan ones in color.

Greenidea hirsuta n. sp.

Apterous viviparous female.—Brownish black, with the head and thorax pale greenish brown. Cornicles blackish brown, darker on the distal half. Body with many long stout setae, which are mostly branched at the tip and curved. Head a little protruding widely on the front, frontal setae somewhat longer than the basal antennal segment. Frontal tubercles absent. Antennae slender; the third
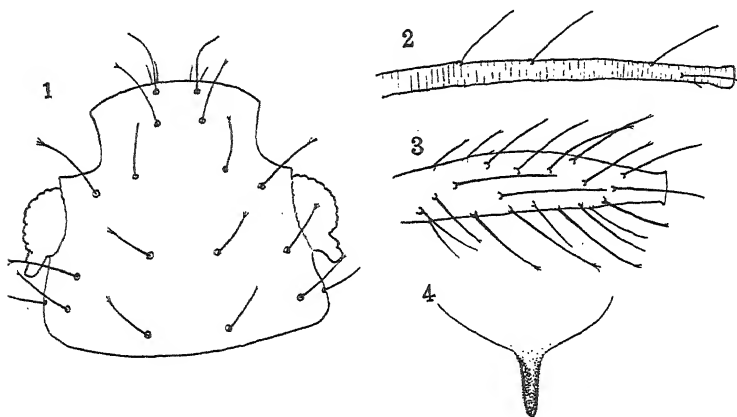
Fig. 1. *Greenidea hirsuta* n. sp., apterous viviparous female: (1) head and pronotum, (2) third antennal segment, (3) cornicle, (4) cauda.

segment a little striate, about 1.8 times as long as the fourth, with 4 long setae and some smaller ones, which are blunt at the tip; the fifth a little longer than the fourth, with two similar long setae and a shorter one; the sixth with the basal part nearly as long as the fifth; the distal part somewhat longer than the third, twice or slightly over twice as long as the basal part. Abdomen subcircular, sclerotized on the dorsum; the setae stout, dark, longer than those on the head. Minute granules present on the venters of thorax and basal part of abdomen. Cornicles about five times as long as wide, a little narrowed towards the base on the basal part, narrowest at the apex, longer than the femur, with a few translucent striae at the base, with spinules almost over the whole surface, with many long dark bristles, which are a little longer than those on the abdomen, and some of which are branched apically. Cauda with a slender process. Anal plate with numerous simple bristles which reach beyond the caudal process. Tibiae indistinctly a little striate.

Body 1.75 mm.   Antenna 1.8 mm.   Cornicle 0.6 mm.   Abdomen 1 mm. wide.

Host plant, an undetermined tree.

Cameron Highlands (5000 ft.): many apterous forms (1.X.1944).

This species has a long caudal process like *G. schimae* Takah. from Formosa, but is different from that species in the color, and in the blunt setae on the antennae, as well as in other characters; and is distinguished from *G. decaspermi* Takah. by the shorter cornicles and other structures.

Eutrichosiphum lithocarpi malayense n. subsp.

Apterous viviparous female.—Black, brownish on the head; cornicles black.   Body widened on the abdomen, with many long bristles, some of which are branched at the tip.   Head a little protruding at the middle part of front, slightly concave at the middle of the protuberance; frontal setae longer than the basal antennal segment.   Frontal tubercles short.   Antennae much shorter than the body, five-segmented; the third segment a little striate, a little shorter than the fourth and fifth together, with over 15 long setae; the fourth nearly as long as the basal part of the fifth, with about 4 long setae; distal part of the fifth about twice as long as the basal part.   Abdomen rounded at the side, sclerotized on the dorsum, with granules on the lateral part of venter; indistinct, more minute granules also present on the dorsum.   Cornicles rather stout, about five times as long as wide, rounded on one side, broadest at the middle part, narrowest at the apex, lacking reticulations, with spinules over the whole surface, with many very long setae, which are longer than those on the body.   Caudal segment rounded.   Tibiae not striate, with many simple setae, some of which are longer than the width of tibia; fore tibiae a little longer and wider than the third antennal segment; hind tibiae longer than the cornicle.

Body 1.5 mm.   Antenna 0.75 mm.   Cornicle 0.45 mm.

Alate viviparous female.—Black, cornicles and stigma black.   The third antennal segment nearly as long as the fourth and fifth taken together, with about 18 long setae, and about 20 large, transversely oval sensoria in a row over the whole length; the fourth a little longer than the basal part of the fifth, with about four long setae; distal part of the fifth about twice as long as the basal part, much shorter than the third.   Cornicles long, moderately swollen on the distal half, narrowest at the apex, nearly as long as the hind tibia, much longer than the third antennal segment, faintly striate on the basal part, with spinules on the distal part, with many very long bristles, which are much longer than those on the body.   Caudal segment rounded.   Legs slender; tibiae not striate, with many long fine setae; fore tibiae a little longer than, but nearly as stout as, the third antennal segment.

Body 1.5 mm.   Antenna 1.2 mm.   Cornicle 0.65 mm.

Host plant, *Quercus* sp.: attacking the young leaf and shoot.

Cameron Highlands (5000 ft.): many apterous and a few alate forms (1.X.1944).

Different from *E. lithocarpi* Maki in possessing branched bristles on the body.

Greenideoida vandermeermohri Takahashi

Alate viviparous female.—Mostly pale greenish white, a little dusky on the head, pro- and mesonota, and on the dorsum of abdomen. Eyes red. Antennae, cornicles, wing veins and stigma black. Body narrow, with setae scarcely or not capitate. Front ocellus ventral. Antennae slender, imbricated, five-segmented; the third segment long, somewhat shorter than the fourth and fifth together, with 4 to 9 circular sensoria in a row on the basal half, which are variable in size; the fourth nearly as long as the basal part of the fifth, without secondary sensoria; the fifth with an oval primary sensorium at the base of the distal part, which is slightly longer than the basal part. Abdomen with minute spinules in short transverse rows on the dorsum. Fore wings narrow, a little dusky at the end of radial sector, imbricated on the marginal area; media obsolete at the basal part, once branched; radial sector somewhat curved; stigma rather slender, pointed apically; hind wings small, narrow, imbricated, with no oblique veins. Cornicles long, slender, cylindrical, striate. Legs slender. Other structures similar to the apterous form.

Body 1.7 mm. Antenna 1.6 mm. Cornicle 1.5 mm.

Host plant, *Bridelia* sp.; attacking the lower side of leaf along the rib.

Kepong, Selangor: many apterous and a few alate forms in small colonies (28.VI.1944).

Previously only the apterous form is recorded from Sumatra (Miscell. Zool. Sumatr., 97, p. 1, 1935).

Greenideoida mesuae n. sp.

Apterous viviparous female.—Yellow, greenish yellow, or almost blackish green. Cornicles dusky yellowish brown, or black, pale on the distal part. Body elongate, a little rounded on the side of abdomen, broadest at the middle of abdomen. Head almost straight or slightly ·convex at the middle of front, on the dorsum with four simple setae between the eyes, and with two pairs of longer setae on the front, which are blunt at the tip and somewhat shorter than the basal antennal segment. Frontal tubercles very short, indistinct, with a seta on the mesal side. Eyes rather small, protruding, with distinct ocular tubercles. Antennae long, slender, striate, as long as, or shorter than, the body, five- or six-segmented; the third segment long, nearly as stout as the tibia, somewhat longer than the fourth, fifth and the basal part of the sixth taken together in six-segmented ones, but nearly as long as the fourth and fifth taken together and much longer than the fore tibia in five-segmented ones, with over 25 setae, the longer ones of which setae are slightly longer than the width of the segment; the fourth as long as the fifth or the basal part of the sixth, with about nine setae; distal part of the sixth about 1.5 times or twice as long as the basal part. Prothorax fused with the head, narrower than the mesothorax. Abdomen with many granules on both surfaces, a few stiff dorsal setae in rows, and with about 15 stiff simple setae on the side, which are nearly as long as those on the front; basal and distal abdominal segments defined. Cornicles long, slender, shorter than the antenna, a

little curved. striate, distinctly narrowed towards the apex, with many
minute spinules in rows on the apical part, with many simple setae except
on the basal part, the longer ones of which setae are nearly as long as
the largest diameter of the cornicle. Caudal segment somewhat
triangular, rounded apically, with some long setae. Legs slender;
trochanters defined; femora narrower than the cornicle; tibiae distinctly
striate, without stout setae at the apex; tarsi with about five setae on the
basal segment.

Body 2–2.1 mm. long, 0.9 mm. wide. Antenna 1.5–2.1 mm.
Cornicle 1–1.6 mm.

Alate viviparous female.—Yellow, black on the head, antennae and
mesothorax, with a very wide black band at the middle of abdomen.
Eyes dark red. Cornicles black, but whitish apically. Legs dusky,
brownish in specimens in balsam. Wings slightly clouded along the
first oblique and stigmatic vein; veins and stigma black. Body
elongate. Head straight on the front, with some stiff setae, which are
very slightly capitate and shorter than the basal antennal segment, and
four of which are near the hind margin of the dorsum. Frontal tubercles
absent. Antennae six-segmented; the third segment a little tapering,
striate, stouter than the tibia, much longer than the fourth and fifth
together, slightly longer than the fore tibia, with 23 to 30 transversely
oval sensoria in a row along the whole length, and with over 25 stiff
setae, which are nearly as long as, or a little shorter than, the diameter
of the basal part of the segment; the fourth slender, as long as the fifth,
with 2 to 5 small oval sensoria in a row about the middle part; basal
part of the sixth a little shorter than the fifth; the distal part a little
over twice as long as the basal part. Abdomen with a few short setae
in rows. Cornicles very long, cylindrical, somewhat tapering on the
distal half, slightly curved, stouter than the femur, much longer than
the tibia, a little shorter than the antenna, not reticulate, with many
setae except on the basal part, which are nearly as long as the diameter
of the basal part. Caudal segment rounded. Legs slender; hind
tibiae striate, with many short setae. Fore wings imbricated narrowly
along the margin; subcosta with 4 to 6 pores in a row about the middle;
the second oblique a little curved; the third once branched, more slender
than other oblique veins, obsolete at the basal part; stigmatic vein
slightly curved, reaching the tip of the wing; stigma not reaching near
the tip; hind wings small, with no oblique, hooklets 3 or 4.

Body 2.1 mm. Antenna 2.1 mm. Cornicle 1.9 mm. Fore wing
2.35 mm.

Host plant, *Mesua ferrea*; attacking the young leaf and branch.

Kuala Lumpur: common, sometimes found in large numbers, being
visited by Oecophylla smaragdina.

Related to *G. ceyloniae* van der Goot, but differs from the brief
original description of that species in the apterous form wanting capitate
setae, and in the alate form with 23 to 30 sensoria on the third antennal
segment, and in other characters.

Aiceona osugii Takahashi

Host plant, *Actinodaphne* sp.?; attacking the young leaf.
Kuala Lumpur (Bukit Nanas): common.

Previously known from Mt. Ari, Formosa (Dept. Agr., Govt. Res. Inst. Formosa, Rept. No. 10, p. 76, 1924).

Readily differentiated from *A. actinodaphnis* Takah. and *A. siamensis* Takah. by the presence of more sensoria on the antennae in the alate form and by the pale greenish yellow apterous form.

Nippolachnus pyri Matsumura

Host plant, *Pyrus granulosa*.
Cameron Highlands (5000 ft.): some apterous forms (6.X.1944).
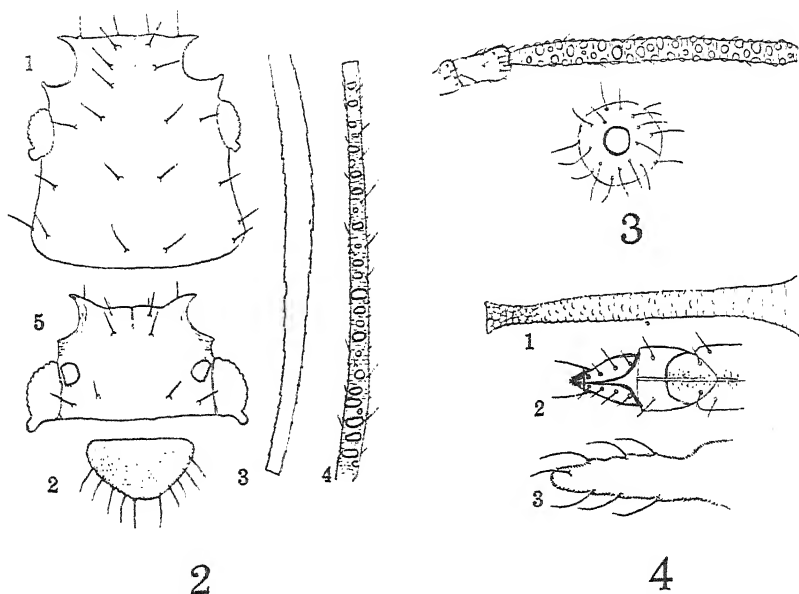
FIG. 2. *Greenideoidea mesuae* n. sp. Apterous viviparous female: (1) Head and pronotum, (2) cauda, (3) cornicle (outline). Alate viviparous female: (4) third antennal segment, (5) head.

FIG. 3. *Aiceona osugii* Takah. Alate viviparous female: third antennal segment and cornicle.

FIG. 4. *Sitobion avenae graminis* n. subsp. Apterous viviparous female: (1) Cornicle, (2) distal part of rostrum, (3) cauda.

Lachnus tropicalis van der Goot

Host plant, *Quercus* sp.; attacking the branch.
Cameron Highlands (5000 ft.): some apterous and alate forms (1.X.1944).

Macrosiphum ibarae Matsumura

Host plant, *Rosa* sp.
Fraser's Hills, Pahan: a few apterous forms (6.VI.1943).

Macrosiphoniella sanborni Gillette

Host plant, Chrysanthemum.
Cameron Highlands (5000 ft.): a few apterous form (26.IX.1944).

Macrosiphoniella yomogifoliae Shinji

Host plant, *Artemisia* sp.
Cameron Highlands (5000 ft.): some apterous forms (1.X.1944).
Different from *M. artemisiae* Boyer in the fewer setae of the cauda.

Sitobion avenae graminis n. subsp.

Apterous viviparous female.—Blackish, slightly with a powder. Dorsum sclerotized, or with many sclerites; antesiphuncular and post-siphuncular sclerites distinct, the latter more developed: a pair of sclerites present at the median area and a lateral one larger, with 2 setae. Dorsal setae short, much shorter and fewer than the ventral ones, stiff, blunt at the tip, in rows. Head slightly protruding at the middle part of front. Antennae black; the third segment not imbricated, with 1 to 3 small sensoria near the base; antennal setae short, as in the typical form. Distal segment of rostrum longer than wide, a little rounded on the side of the basal half, slightly concave on the side of the distal half, a little shorter than the penultimate segment, much shorter than the second tarsal segment. Cornicles slender, reticulate at the distal one-fifth or less, about 1.5 times as long as the cauda, with no distinct flange at the tip, black. Cauda normal in shape, black, with 3 pairs of lateral setae and an apical one. Tibial setae stiff, shorter than the width of tibia; tarsi with 3 spine-like setae on the basal segment.

Body 2.2–2.4 mm. Antennae about 3 mm   Cornicle 0.55 mm. Hind tibia 1.5 mm.

Host plant, a species of the Gramineae; attacking the flower stalk.
Cameron Highlands (5000 ft.): some apterous forms (2.X.1944).
Differs from the typical form in the black cauda.

Dactynotus cameronensis n. sp.

Apterous viviparous female.—Black; antennae, cornicles and cauda black. Legs pale brown on the basal halves of femora and tibiae, black on the remaining parts. Many small subcircular sclerites present at the bases of dorsal setae; postsiphuncular sclerites large. Head not imbricated, with 4 simple setae in a row between the eyes, and a pair between the posterior parts of frontal tubercles, which setae are stiff or a little curved and much shorter than the second antennal segment. Frontal tubercles developed, normal. Antennae long, slender, with some setae which are as long as, or shorter than, the width of third segment; the third segment nearly as long as the fourth and fifth taken together, not imbricated, with about 20 setae and about 25 very small circular sensoria scattered mostly on the basal half or two-thirds except at the base; the fourth somewhat imbricated, equal in length to the fifth, about thrice as long as the basal part of the sixth; distal part of the sixth shorter than the third. Rostrum reaching beyond the hind coxae; distal segment slender, a little tapering, subequal in length to the penultimate. Cornicles cylindrical, rather stout, widened towards the base on the basal half or third, nearly as long as the third antennal segment, much longer than the cauda, imbricated, reticulate on the distal fourth. Abdomen with many setae in rows. Cauda normal in shape, constricted near the basal part, with about 15 setae. Legs long,

slender, with many stiff setae; tibiae stouter than the third antennal segment; hind tibiae narrowed distally, with stiff setae which are mostly shorter than the width of tibiae, tarsi normal.

Body 2.5 mm.   Antennae 3.3 mm.   Cornicle 1.0 mm.

Alate viviparous female.—The third antennal segment with about 60 small sensoria scattered over the whole length except at the basal and distal small parts; the fourth without sensoria.   Cornicles widened towards the base on the basal part.   Other characters as in the apterous form.

Host plant, a large plant of the Compositae.

Cameron Highlands (5000 ft.): some apterous forms and an alate form (29.IX.1944).

Closely related to *D. gobonis* Matsumura, differing, however, in the third antennal segment with fewer sensoria, which are scattered mostly on the basal half or two-thirds in the apterous form, as well as in the simple setae on the body.   Differentiated from *D. taraxaci* Kalt. by the presence of a distinct postsiphuncular sclerite; from *D. solidaginis* Fab. by the longer third antennal segment; and from *D. jaceae* L. by the fewer setae on the cauda, the distal part of the sixth antennal segment being much shorter than the third, and by other characters. Also different from *D. lactucicola* Strand from Formosa in the presence of more sensoria on the antennae in the apterous form and in some other structures.

Dactynotus compositae Theobald

Host plant, a plant of the Compositae.
Kluang, Johore: common (XI.1945).

Myzus circumflexum Buckton

Host plant, *Wormia* sp.?
Cameron Highlands (5000 ft.): 2 apterous forms (1.X.1944).

Myzus sp.

Host plant, a composite.
Cameron Highlands (5000 ft.): some nymphs (26.IX.1944).
Probably *M. persicae* Sulzer.

Megoura citricola van der Goot

Host plant, *Cinnamomum* sp.
Singapore (Tidjschr. v. Ent., 60: 115, 1918,).   Not collected by the author.

Megoura simplocois van der Goot

Host plant, an undetermined tree.
Cameron Highlands (5000 ft.): a few apterous forms (24.IX.1944).
Closely resembles *M. citricola* van der Goot, but differs in the cauda with 3 pairs of lateral setae.

Micromyzus nigrum van der Goot

Host plant, Maidenhair fern.
Singapore (Corbett and Gater, Dept. Agr. Fed. Malay St., Bull. No. 38, p. 6, 1926).   Not collected by the author.

Pentalonia nigronervosa Coquerel

Host plants, banana, *Alpinia* sp., *Caladium*.

Kuala Lumpur, Sungei Buhlo, Setapah, Selangor: common, but occurring in small colonies.

Rhopalosiphum maidis Fitch

Host plant, corn.

Recorded from Malaya by Corbett and Gater (Dept. Agr. Fed. Malay St., Bull. No. 38, p. 6, 1926), but not found by the author.

Hyalopterus arundinis Fabricius

Host plant, *Phragmites* sp.

Kuala Lumpur, Sungei Besi, Selangor: common.

Brachysiphoniella graminis Takahashi

Host plant, *Leersia* sp.

Malacca: many apterous forms and an alate form (12.VIII.1943); Kuala Sleh, Selangor: many apterous form (18.IV.1944).

Toxoptera aurantii Boyer

Host plants, Mangosteen, *Thea, Citrus. Artocarpus integrifolia, Ficus pumila,* a composite, etc.

Singapore; Kuala Lumpur, Kepong, Dusun Tua, Ulu Gombak, Selanger; Fraser's Hills, Cameron Highlands: common, sometimes attended by *Oecophylla smaragdina* or *Crematogaster* sp.

Toxoptera citricida Kirkaldy

Host plant, *Citrus*.

Kuala Lumpur: some apterous and alate forms (2.I.1943).

Very closely related to *T. aurantii* Boyer, with peculiar sculptures on the abdomen, and should be included in this genus, though the media of fore wings is usually twice branched as in *Aphis*.

Aphis gossypii Glover

Host plants, *Hibiscus rosa-sinensis*, cotton, *Melastoma* sp., *Colocasia, Solanum* spp., *Jacaranda mimosaefolia*, a composite.

Kuala Lumpur; Telakanson, Krian, Perak; Fraesr's Hills, Cameron Highlands; Rempang, Riouw Islands: common.

Aphis malvoides van der Goot

Host plant, a composite (*Bidens* ?).

Singapore, Kuala Lumpur: common.

Aphis glycines Matsumura

Host plant, soy bean.

Puchong, Selangor: many apterous and a few alate forms (25.VII.1944).

Aphis laburni Kaltenbach

Host plants, Beans.

Kuala Lumpur, Dusun Tua, Selangor: common.

Previously recorded from Johore as *A. medicaginis* Koch (Philippine Jl. Sc., 21: 421, 1922).

Aphis nerii Boyer

Host plant, *Asclepias crassavica*.

Singapore: a few specimens collected by Corbett and Gater (19.XII.1925).

Aphis saliceti Kaltenbach

Host plant, *Salix tetrasperma*.

Dusun Tua, Selangor: many yellowish apterous forms and an alate form (23.V.1943).

Some of the apterous forms are provided with small sensoria chiefly on the distal half of the third antennal segment and may be regarded as intermediate forms between the alate and apterous females.

Aphis odinae van der Goot

Host plant, *Cinchona*.

Cameron Highlands (5000 ft.): a few apterous forms (II.XI.1943).

Aphis sacchari Zehntner

Host plants, sugar cane, sorghum.

Kuala Lumpur, Gombak, Kuala Selanger: common.

Aphis bambusae Fullaway

Host plant, bamboo.

Singapore, Kuala Lumpur, Lawan, Selangor; Krian, Perak: common, but occurring in small numbers.

Aphis pahanensis n. sp.

Apterous viviparous female.—Brownish purple; antennae pale brown, darker at the apices of segments; legs mostly pale brown. In specimens treated with potash, dorsum without patches, cornicles and cauda pale brown. Body and its appendages with much white cottony wax in life. Body normal in shape, with long fine setae. Head smooth on the surface, not protruding at the front, with setae longer than the basal antennal segment. Frontal tubercles absent. Antennae slender, six-segmented, with many long fine setae which are shorter than the fourth segment; the third segment a little imbricated, a little narrower and much shorter than the fore tibia, nearly as long as, or somewhat shorter than, the fourth and fifth taken together, without sensoria, with about 15 long fine setae; the fourth as long as the fifth, with about 5 similar setae; basal part of the sixth a little shorter than the fifth, as long as the tarsus; the distal part nearly as long as the third, 2.5 times as long as the basal part. Rostrum short, stout, reaching the middle coxae; the distal segment longer than wide, tapering, pointed, nearly as long as the penultimate. Abdomen with setae in irregular rows on the dorsum, about 4 setae present between the cornicles. Cornicles short, as long as the cauda, somewhat widened towards the base, about twice as long as wide at the apex, nearly as wide as the femur, as long as, or a little longer than, the dorsal setae of abdomen, scarcely or not striate, with no flange distinct. Cauda a little tapering rounded at the apex slightly constricted, with 5 or 6 setae. Tibiae slender with many long fine setae.

Body 1.25 mm. Antennae 0.77 mm. Hind tibia 0.5 mm.

Host plant, a plant of the Gramineae resembling *Arundinaria*; attacking the lower side of leaf.

Cameron Highlands (5000 ft.), Pahan: some apterous forms (26.IX.1944).

Closely related to *A. arundinariae* Takah. but differs in the body being provided with much cottony wax, the dorsum without patches at the bases of setae, the cornicles with no apical flange, the six-segmented antennae, with the distal part of the last segment being as long as the third, the shorter setae on the body and antennae and in other characters.

Oregma bambusae Buckton

Host plant, bamboo: attacking the young shoot and the lower side of young branch.

Kuala Lumpur: sometimes occurring in large numbers, attended by *Dolichoderus*.
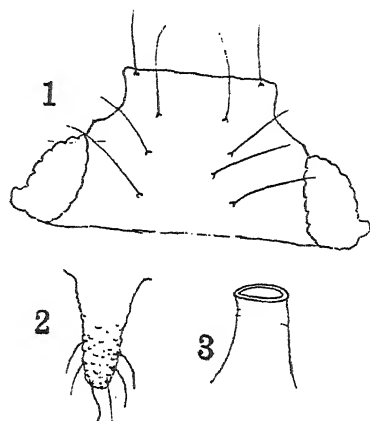
FIG. 5. *Aphis pahanensis* n. sp. Apterous viviparous female: (1) head, (2) cauda, (3) cornicle.

Oregma pendleburyi n. sp.

Apterous viviparous female.—Dorsum sclerotized over the whole surface, with numerous granules. Frontal horns distinctly diverging, tapering, but rounded at the tip, as long as, or slightly longer than, the basal antennal segment. Antennae four- or five-segmented. Thoracic and basal six abdominal segments each sometimes with 1 to 4 small oval wax-pores on the dorsum, the eighth abdominal tergite sometimes with 3 to 5 small wax-pores in a group at the middle. Cornicles small.

Body 2.7 mm.

Host plant, bamboo.

Kedah Peak (3000 ft.): many apterous forms collected by H. M. Pendlebury (15.III.1928).

Differs from *O. bambusae* Buckton in the whole dorsum being sclerotized and in the smaller cornicles, as well as in the first stage nymph with granules over the whole dorsum, with longer horns and with

the fore femora being much swollen. Distinguished from *O. sundanica* van der Goot by the larger body, and by the distal segment of rostrum being stouter, a little longer than wide and usually a little rounded on the side.

Oregma gombakana n. sp.

Apterous viviparous female.—Blackish brown, somewhat purplish, with small patches of wax along the side and on the dorsum. Body oval, stout, convex dorsally, distinctly sclerotized on the whole dorsum, slightly granular on the anterior part of dorsum. Head and prothorax

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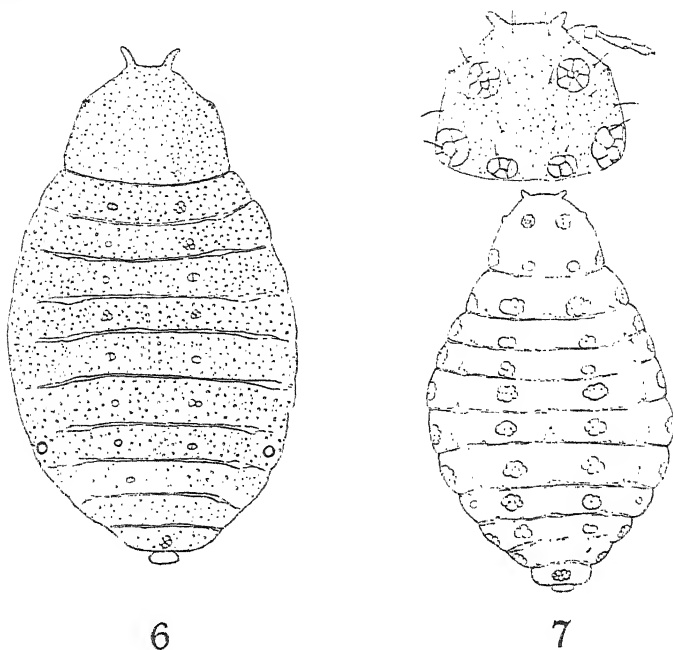
Fig. 6. *Oregma pendleburyi* n. sp. Apterous viviparous female.

Fig. 7. *Oregma gombakana* n. sp. Apterous viviparous female. Body and cephalo-prothorax.

with some groups of areolations on the dorsum, which are much smaller than the wax-pore and about 3 to 14 in number in each group. Frontal horns longer than wide, diverging, as long as the basal antennal segment, bluntly pointed or rounded at the tip. Eyes of three facets Antennae nearly as long as the fore femur, four-segmented; the third segment widened distally, with a few short setae; the fourth a little shorter than the third, shorter than the fore tarsus. Distal segment of rostrum stout, nearly parallel on the sides, rounded at the side of apex, pointed at the middle of apex, longer than wide, a little shorter than the penultimate segment. Abdominal segments distinct, with some rather short stiff setae in a row; the seventh tergite with 3 setae; the eighth with a pair of setae, between which a group of wax-pores is located.

Cornicles small, smaller than the wax-pore. Cauda short, much constricted basally, with about 8 long setae along the hind margin, of which 2 at the middle are much longer. Anal plate deeply bilobed, with 7 or 8 setae on each lobe. Legs rather short and stout; femora with many faint areolations; tibiae with some fine setae which are shorter than the width of tibia; tarsi slightly striate, the basal segment with 2 median and 2 similar, but longer, lateral setae in the fore pair, with a median and 2 longer lateral setae in the middle pair, and with only a pair of long setae in the hind pair. Wax-pores large, but sometimes small or scarcely developed, in a compact group on the side and in a pair of groups on the dorsum of each segment, but the seventh abdominal tergite with no dorsal group and the eighth with a median dorsal group only; numbers of wax-pores in each group about as follows: (dorsal group) 1 to 7, usually 4 to 6, on thorax, 2 to 7 on abdomen, but 3 to 8 on the eighth segment, (lateral group) 5 or 6 on thorax, 3 to 5 on abdomen.

Body 1.7–1.8 mm.

Host plant, bamboo: attacking the basal part of the upper side of leaf.

Ulu Gombak, Sungei Tua Selangor: some apterous forms in small colonies (17.IV., 11.V., 18.VII.1944).

Distinguished from *O. bambusae* by the dorsum sclerotized over the whole surface, with large wax-pores, and by other characters, and from *O. sundanica* van der Goot by the presence of wax-pores on the dorsum. Different from *O. montana* van der Goot in the colour, the fewer wax-pores which are larger than the cornicle, and in other structures.

Oregma sundanica van der Goot

Host plants, a plant of the Zingiberaceae, *Amomum*.

Singapore; Ulu Gombak, Kepong, Selangor; Fraser's Hills: common, sometimes occurring in large colonies.

Oregma nicolaiae Takahashi

Host plant, *Elattaria cardamomum*.

Kuala Lumpur (Insecta Matsumurana, 15, p. 149, 1949). Not collected by the author.

Trichoregma nipae van der Goot

Host plants, *Zalacca*, coconut palm, *Elaeis*, Nipah palm.

Singapore; Sunegi Buhlo, Klang, Ulu Gombak, Kuala Lumpur, Kuala Selangor, Selangor; Fraser's Hills: common, sometimes occurring in large colonies.

Trichoregma muiri van der Goot

Host plants, *Amomum, Languas*.

Singapore, Fraser's Hills.

Trichoregma musae Takahashi

Host plant, a plant of the Zingiberaceae.

Sungei Buhlo, Serdang, Damansara, Ulu Gombak, Selangor: common.

Different from the Sumatran specimens in the fewer (5 or 6) setae on the cone of cornicle and in the wax-pores on the head and thorax being narrower and closely arranged in rows.

Trichoregma singaporensis van der Goot

Host plant, bamboo.

Singapore: many apterous forms (2.III.1944).

Trichoregma rhapidis van der Goot

Host plants, *Cocos, Elaeus, Kentia, Calamus* sp.

Singapore; Kuala Lumpur, Ulu Gombak, Selangor: many apterous and some alate forms (II. and IV.1944).

Trichoregma malaccensis n. sp.

Apterous viviparous female.—Dark purplish brown, with much wax along the body margin. Body oval. Head and prothorax fused together, with about 20 long fine dorsal setae, which are as long as, or a little longer than, the frontal horns. Horns pointed, a little diverging, rather slender, as long as, or slightly longer than, the basal antennal segment. Eyes protruding. Antennae four-segmented; the third segment a little longer than the fourth, narrowed towards the base, often with a distinct constriction near the base, with about 3 setae on the distal half; the fourth with 2 setae on the basal part. Distal segment of rostrum short, a little widened towards the base, somewhat shorter than the penultimate segment. Abdomen not so widened, slightly sclerotized around the bases of setae on the dorsum, with 2 setae between the rows of wax-pores on the sixth and seventh tergites, but with 4 setae in a row between the cornicles on the fifth; the eighth a little sclerotized, with the rows of wax-pores very closely placed, a pair of setae at the middle in front of the pores, and with 2 lateral setae at the hind margin. Wax-pores large, arranged in an irregular row on the side of each segment, oval or irregularly narrowed in shape, mostly larger than the cauda; those on the sixth and seventh abdominal segments sometimes a little larger, those on the sixth located transversely behind the cornicles; numbers of wax-pores in each row about as follows: 2 to 5 on head, 3 or 4 on porthorax, 3 on mesothorax, 3 or 4 on metathorax, 3 on basal abdominal segment, 4 on second to seventh, 4 to 6 on eighth. Cornicles separated from the rows of wax-pores, with 2 setae on the cone. Cauda constricted basally, with about 9 long setae. Anal plate divided. Legs with some long fine setae; tibiae stouter than the third antennal segment; tarsi short, with 2 long setae on the basal segment.

Body 1.0 mm.

Host plant, bamboo.

Malacca, Singapore: some apterous forms (IV.1943; V.1944).

This species is characterized by the rows of wax-pores being located transversely behind the cornicles on the sixth abdominal segment and by the third antennal segment usually with a distinct constriction near the base.

Trichoregma flava n. sp.

Apterous viviparous female.—Entirely yellow. Body oval, not so expanded on the abdomen. Head and prothorax sclerotized on the dorsum, with about 18 moderate setae; meso- and metathoraces and basal four abdominal segments each with a pair of large wide transverse sclerotized parts on the dorsum, those on the fourth abdominal segment united: the fifth to seventh each with a large transverse sclerotized part

on the dorsum; these sclerotized parts smooth, separated from the lateral ones of wax-pores. Frontal horns conical, rather stout, diverging, sharply pointed, nearly as long as the basal antennal segment. Eyes a little protruding. Antennae short, shorter than the width of head across the eyes, four-segmented; the third segment narrowed towards the base, longer than the fourth, with a few setae on the distal half; the fourth not narrowed basally, the basal part about twice as long as the distal. Abdomen with 2 to 4 short setae in a row on each tergite, sclerotized on the eighth tergite. Wax-pores large, circular or subcircular, in rows on the side only; numbers of wax-pores in a row about as follows: 1 or 2 on prothorax, 2 or 3 on meso- and metathoraces, 3 or 4 on basal seven abdominal segments, 4 or 5 on the eighth; the rows usually distinctly separated, with a pair of setae between them on the eighth. Cornicles small, low, at the apex as large as, or smaller than, the wax-pores; the cones or basal sclerotized parts separated from, or united with, the lateral sclerotized parts of wax-pores, but united with the dorsal sclerotized parts, with 1 to 4 setae. Cauda and anal plate normal. Legs short; tibiae as long as the femur and trochanter together, fore tibiae a little shorter than the antennae; fore tarsi with 4 setae on the basal segment, of which the median 2 are shorter; middle and hind tarsi with a pair of long setae on the basal segment, but the middle pair sometimes with also a median one.

Body 1.3 mm.

Host plant, bamboo: attacking the basal part of the lower side of leaf.

Taiping, Perak: many apterous forms (8.XI.1943); Malacca: a few smaller apterous forms (IV.1943).

Differs from other species of the genus in the presence of distinct sclerotized parts on the dorsum.

Trichoregma lutescens van der Goot

Host plant, bamboo.

Kuala Lumpur, Kepong, Sungei Tua, Selangor: common.

The apterous form is very variable in color, and *T. striata* van der Goot may be a form of this species.

Trichoregma salatigensis van der Goot

Host plant, bamboo.

Malacca; Tanbun near Ipoh, Perak; Dusun Tua, Selanger: many apterous forms.

Trichoregma pallida van der Goot

Host plant, bamboo.

Kuala Lumpur, Fraser's Hills: common, but usually occurring in small colonies.

Different from the Malayan specimens of *T. salatigensis* van der Goot in the presence of lateral wax-pores in rows on somewhat sclerotized parts on the thorax and abdominal segments. The aphid recorded as *T. salatigensis* van der Goot from Siam (Govt. Agr. Res. Inst. Formosa, Rept. No. 78, p. 16, 1941) may be this species.

Ceratovacuna lanigera Zehntner

Host plants, sugar cane, *Saccharum arundinaceum.*
Kuala Lumpur, Serdang, Batu Caves, Selanger, Cameron Highlands: common.

Cerataphis freycinetiae van der Goot

Host plant, *Freycinetia* sp.
Singapore: some apterous forms (26.V.1944).

Cerataphis lataniae Boisduval

Host plants, palms.
Kuala Lumpur, Sungei Buhlo, Ulu Gombak, Selangor: common, sometimes protected with shelters by *Crematogaster.*

Some apterous forms collected on an abnormal host, *Ficus* sp. (*Ficus fistulosa* ?) at Kuala Lumpur (7.III.1943) may represent a separate form and the description is given below.

Apterous viviparous female.—Body similar in shape and colour to that on palms. Submarginal dorsal setae nearly as long as the basal antennal segment. Frontal horns conical, pointed, expanded basally, nearly parallel on the mesal sides, slightly separated from each other at the base, almost as long as the basal antennal segent. Head on the venter with a pair of short spine-like setae between the antennae, 2 fine setae laterad of each horn, and with 2 or 3 pairs of similar setae behind the spine-like ones. Marginal wax-pores circular or subcircular, not elongate, 13 to 16 in number along the margin of the eighth abdominal tergite. Cauda with 3 pairs of setae at the hind margin, of which the last pair is much longer. Tarsi with 4 long fine setae at the apex, which are very slightly capitate; the basal segment with 2 median long stout setae and a pair of very long fine lateral setae in the fore pair, a median seta and a pair of lateral ones in the middle pair, and with only a pair of long fine ones in the hind pair.

Body 1.4–1.5 mm.

Ceratoglyphina bambusae van der Goot

Host plant, bamboo.
Kuala Lumpur (4.IV.1943), Malacca (30.IV.1943): some apterous forms.

Glyphinaphis bambusae van der Goot

Host plant, bamboo.
Singapore (Tijdschr. v. Ent., 60: 113, 1918). Not collected by the author.

Aleurodaphis blumeae van der Goot

Host plant, *Blumea* sp.
Cameron Highlands (5000 ft.): many apterous forms (IX. and X.1944).

Thoracaphis kayashimai n. sp.

Apterous viviparous female.—Closely related to *T. setigerus* Takah. (Philip. Jl. Sc., 48: 72, 1932), differing, however, in the following characters: Dorsum not reticulate, with 3 pairs of circular markings and

closely with convolute markings on the median area of thorax except on the median longitudinal narrow part, which part is not reaching the head and abdomen. Legs black; hind femora over twice as long as wide; hind tibiae a little longer than the femur, over twice as long as the tarsus; hind tarsi longer than wide, not reaching the hind end of body, somewhat narrowed on the distal half, rounded apically.

Body about 0.5 mm.

Host plant, *Quercus* sp.; attacking the lower side of leaf.

Cameron Highlands (5000 ft.): many apterous forms (1.X.1944).

Apparently different from *T. elongatus* Takah. in lacking conical spines on the median area of dorsum. Named after Mr. I. Kayashima who assisted the author's work in Malaya.
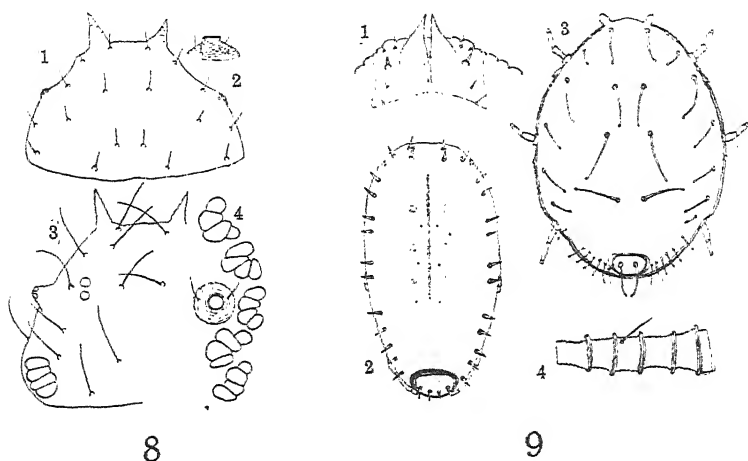
Fig. 8.   *Trichoregma flava* n. sp. Apterous viviparous female: (1) head and pronotum, (2) cornicle. *Trichoregma malaccensis* n. sp. Apterous viviparous female: (3) head and pronotum, (4) cornicle and wax-pores.

Fig. 9.   *Cerataphis lataniae* Boisduval on *Ficus*. Apterous viviparous female: (1) lower side of front. *Thoracaphis kayashimai* n. sp. Apterous viviparous female: (2) dorsal view. *Thoracaphis flavus* n. sp. Apterous viviparous female: (3) dorsal view. *Astegopteryx fransseni kepongensis* n. subsp. Alate viviparous female: (4) fourth antennal segment.

Thoracaphis flavus n. sp.

Apterous viviparous female.—Pale yellowish brown, with no secretion evident. Oval, flattened, very thin, not sclerotized. Head, thorax and basal seven abdominal segments entirely fused together. Dorsum with many small, but distinct granules over the whole surface except on about 4 pairs of large oval parts on the median area and on the eighth abdominal tergite, which granules are provided with some small pointed spines; 4 pairs of long stout setae on the median area, which are capitate or narrowed on the distal part and blunt at the tip, and a pair on the head is longer than the antenna and as long as, or a little shorter than, the space between themselves; bases of these setae larger than the granules; 12 setae arranged in a row along the sub-

marginal area on each side, of which 2 posterior ones are not capitate, and 6 or 7 posterior ones are shorter and near the hind end of body; the eighth abdominal tergite separated, small, short, much wider than long, not protruding, with a pair of rather long capitate setae about the middle. Antennae horn-like, not segmented, stout, subconical, rather large, pointed apically, diverging, shorter than the femur, about 1.5 times as long as wide, marginal. Eyes not recognizable. Cornicles absent. Cauda short, wider than the anal lobe, a little constricted, with some short setae. Anal plate distinctly divided, each lobe wider than long, rounded on the margin, with some short setae. Legs exposed; hind femora over twice as long as wide; hind tibiae longer than the femur; tarsi very short, wider than long, not segmented, with 2 setae at the apex.

Body 0.5 mm.

Host plant, *Quercus* sp.; attacking the lower side of leaf.

Cameron Highlands (5000 ft.): many apterous forms (1.X.1944).

This species is characterized by the very thin flattened body, and much differs from *T. depressus* Takah. in the shape of body, the dorsum with granules and capitate setae, and in many other characters.

Thoracaphis malaynus n sp.

Apterous viviparous female.—Black, somewhat with a brownish tinge, shining, sclerotized, with no wax evident. Body subcircular, slightly wider than long, thick, flattened on the dorsum, slightly protruding at the hind end. Cephalothorax occupying most of body, with no trace of segments, with a pair of fine setae at the anterior margin between the antennae, four transverse rows of setae on the median area (4 setae in each row), and some setae along the margin of dorsum; these setae rather or moderately long, simple, a little curved, very thin at the apical part; some minute mosaic-like markings on the lateroanterior and lateroposterior parts of dorsum. Body with a narrow rim along the whole margin on the venter. Antennae slender, somewhat shorter than the space between themselves, laid along the anterior margin of body, visible from above, basal segments not distinct, the third segment with a small sensorium at some distance from the apex. Eyes marginal, of three facets. Abdomen scarcely defined from the thorax; basal seven segments fused together, usually with a short median seta at the anterior part and, with 4 setae in a row along the lateral margin, and with a pair of setae along the hind margin; the eighth tergite separated, somewhat shorter than the basal fused part of abdomen, rounded on the margin, with 4 setae along the margin and with a very narrow rim on the lateral margin. Cornicles very small, as large as the bases of setae on the abdomen. Cauda much larger than the anal lobe, constricted, straight at the hind margin, with about 6 pairs of long fine setae on the posterior part. Anal plate deeply divided, each lobe rounded on the margin, wider than long, with about 7 fine setae on the lateral half. Legs exposed, short, with a few short fine setae; femora over twice as long as wide, slightly narrowed toward the base; tibiae longer than the femur; tarsi longer than wide, segmented, with distinct claws and thin long digitules which are not capitate.

Body 1.3 mm.

Host plant, *Quercus* sp.; attacking the branch.

Cameron Highlands (5000 ft.): some apterous form (1.X.1944).

Related to *T. machili* Takah., but differs from that species in the absence of dorsal papillae, the fewer setae, and in other structures.

Thoracaphis gooti n. sp.

Apterous viviparous female.—Black, with much white wax along the margin. Subcircular, a little longer than wide, somewhat narrower anteriorly, depressed, sclerotized, with very small irregular indentations on the margin. Thorax occupying over half the body; meso- and metanota and basal seven abdominal segments faintly discernible; abdomen not well defined from the thorax, basal two segments much longer than the following five segments, but much shorter than the thoracic segments; the eighth tergite distinctly separated, rounded on the margin, not protruding, with no marginal rim. Dorsum very roughly corrugated except on the eighth tergite, but not so distinctly, without granules; a pair of spines present near the front end and near the lateral margin of each thoracic segment; 4 similar spines between the eyes; a similar one near the lateral margin of each of basal seven abdominal segments, 4 similar ones on the eighth tergite; the spines conical, slender, pointed, short, subequal in length, very slightly narrowed at the base; thoracic and basal two abdominal segments each with a pair of simple fine setae on the median area, which are much longer than the spines and subequal in length. Eyes marginal, of three facets. Antennae on the venter, slender, as long as the space between themselves, three- or four-segmented; the fourth segment shorter than the third; the 3rd and 4th together as long as, or longer than, the fore femur. Cornicles not recognized. Cauda wider than long, somewhat constricted, with some long setae. Anal plate deeply bilobed, the lobes as long as wide, rounded, with many very long stiff setae. Genital plate large, rounded on the hind margin, as wide as the eighth tergite, sclerotized, reaching beyond the hind margin of the eighth tergite. Legs entirely concealed under the body; trochanters fused with the femora; hind legs distinctly longer, reaching the eighth tergite; hind femora as long as, or shorter than, the tibia; hind tibiae rather slender; tarsi distinctly two-segmented, with 3 setae on the basal segment, the median one of which is spine-like; tarsal digitules long, thin, knobbed; claws slender.

Body 1 mm.

Host plant, *Quercus* sp.; attacking the lower side of leaf.

Cameron Highlands (5000 ft.): many apterous forms (4.X.1944).

Named after Dr. P. van der Goot, who much contributed to the study of Aphididae of Malaysia. Related to *T. lithocarpi* Takah., but differs as follows: Dorsum not granular, with 4 spines on the eighth abdominal tergite. Dorsal setae on the median area longer than the submarginal spines. Body a little longer than wide, somewhat narrower anteriorly. Distinguished from *T. cheni* Takah. by the wider body, the cornicles wanting, the dorsum not mosaic-like on the surface, with the spines subequal in length, the distribution of spines on the head being different, and by other characters.

Astegopteryx fransseni kepongensis n. subsp.

Alate viviparous female.—Head with a pair of very short spine-like setae on the front, and with about 14 to 18 short setae on the dorsum, of which a pair near the front ocellus is sometimes longer and as long as the basal antennal segment. Front ocellus smaller than the dorsal ones, on a small protuberance. Antennae normal; the third segment slightly wider than the fore tibia; sensoria as follows: III–17–22, IV–2–6, V–0–3; setae as follows: III–4, IV–2, V–1+3 (at apex). Distal segment of rostrum about 2.2 times as long as wide, as long as or very slightly longer than and much more slender than the penultimate segment. Hind wings with 2 hooks. Four to six setae present around the cornicle. Cauda rounded with about 17 long setae. Anal plate scarcely sinuate, with 6 to 10 setae on each side. Genital plate somewhat sclerotized, with about 11 to 16 setae in a row at the hind
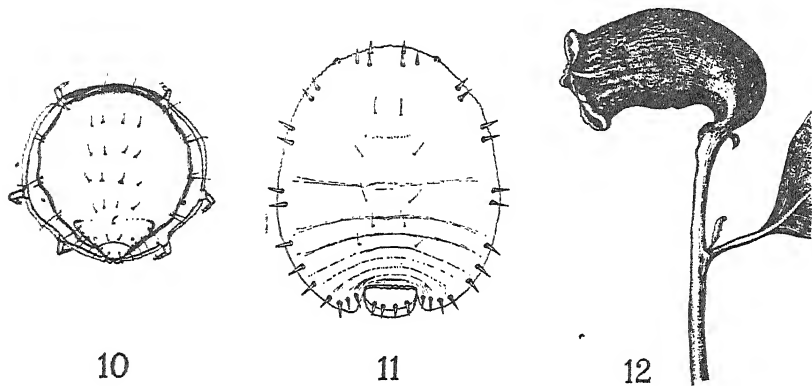
Fig. 10.   *Thoracaphis malaynus* n. sp.   Apterous viviparous female: Dorsal view.

Fig. 11.   *Thoracaphis gooti* n. sp.   Apterous viviparous female: Dorsal view.

Fig. 12.   Gall of *Astegopteryx fransseni kepongensis* n. subsp.

margin and with 3 to 5 setae at the middle part of the anterior half. Other characters as given in the description of *A. fransseni* Lambers (Miscell. Zool. Sumatra, 76, p. 2, 1933).

Host plant—*Styrax benzoin*; producing a single gall at the apex of the branch.

Kepong, Selangor: many alate forms (29.VIII.1943); Serdang, Selangor: a few alate forms (9.VI.1944).

Differs from the figure of *A. fransseni* Lambers in the antennae being slightly more slender and in the primary sensorium on the fifth antennal segment being narrower and transverse. The gall is greyish green, consisting of a single depressed bag, which is about 20–25 mm. long and 14 mm. wide, with a narrow opening at the apex.

Described from specimens from Kepong. The alate forms taken at Serdang are slightly smaller and the third antennal segment is slightly longer than the fourth and fifth taken together, with about 15 sensoria.

Tetraneura sp.

Cameron Highlands (5000 ft.): a broken alate form resting on an onion plant (11.XI.1943).

Probably identical with *T. hirsuta* Baker.

Pineus laevis Maskell

Host plant, *Pinus* sp. imported from Sumatra.

Fraser's Hills: apterous forms abundant (VI. and IX.1943).

LA BIOLOGIE DES DIPTÈRES, by E. Séguy. Encyclopédie Entomologique (Paul Lechevalier, Paris), ser. A, xxvi. 609 pages, 10 plates, 225 text figures. 1950. 4000 francs.

This is an ambitious work, by an outstanding French authority in the field of dipterology, and it fills an important void that has existed in that field. Taxonomists have had to spend so much time in clarifying the status of the species with which they have been concerned that the biologies of most insects have had to be neglected, at least so far as a comprehensive treatment is concerned. Some notable exceptions, as in the ants, termites, mayflies, and mosquitoes, occur, but the biological information on most groups of Diptera is extremely scattered and hard to find. Monsieur Séguy's work brings together a vast amount of information into a single volume, logically treated and easy to read. An extensive list of citations is given in addition to special reference lists at the ends of chapters and sections, and an analytical index, which appears to be adequate, is appended.

Ten chapters (pp. 9–211) are devoted to the morphology (particularly internal) and physiology of the egg, larva, pupa, and adult, and to such subjects as reproduction, the hatching of the egg, and eclosion. But slight mention is made of embryology. The next nine chapters (pp. 212–470) are devoted to the ecology, geographical distribution, media (aquatic and terrestrial), and special habits and habitats (including cavernicolous, "microcavernicolous," domestic, predatory, haematophagus, and parasitic habits), of flies. A final chapter (pp. 471–527) is devoted to a brief survey and characterization of the families.

The book is worthy of the efforts of Monsieur Séguy; it is well-written, well-planned, meaty, and readable. It is accurately and artistically illustrated, and some of the color plates are particularly impressive. A large part of the preparation, however, seems to have been done prior to or during World War II, as reference to literature published since 1940 and utilization of material published in that literature is scant. The absence of many of the important recent American publications is especially notable. In general, American material seems to be treated less fully and less accurately than European: for example, the distribution of *Dermatobia* (p. 241, fig. 112) is shown as extending too far northward (well into the United States) and *Anopheles quadrimaculatus* and *punctipennis* (the latter given erroneously, instead of *freeborni*, as one of the important vectors of malaria) belong to the Sonoram subregion, as interpreted by Séguy, rather than to the Nearctic. There are other errors, but what work of this magnitude is without them?—M. T. J.

NYMPHAL MITES OF THE GENUS UROPODA
ATTACHED TO A CERAMBYCID BEETLE

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On August 5, 1948, Mr. William Helps, a student at McMaster University, captured a male sawyer beetle, *Monochamus notatus* Drury, at Aylmer, Ontario. When examined it was seen to be covered with a mass of reddish mites which appeared to interfere in no way with its movements, since it was taken in flight and remained active when caught. The beetle was pinned and placed in a collection at McMaster University. When it was examined under a binocular microscope the following approximate counts of mites were made on various regions of the body: top of prothorax, 100; bottom of prothorax, 100; left elytron, 200; right elytron, 50; mesosternum, 50; metasternum, 55, making a total of 555 mites (fig. 1). On some areas of the body the mites were so closely crowded that they overlapped one another, some being tipped onto their edges. Each mite was attached to the integument of the beetle by a small white cord projecting from its posterior end (fig. 2). The mites were firmly attached and scraping with a needle was required to dislodge them.

Several mites were removed from the beetle and placed in preservative and were sent to Dr. H. H. J. Nesbitt of Carleton College, Ottawa, and to Dr. E. W. Baker of the Bureau of Entomology and Plant Quarantine, who kindly identified them as nymphs of the genus *Uropoda*. This assemblage of mites on the beetle is evidently a case of attachment for the purpose of transportation as described by Banks (1905), who points out that "some genera (as *Uropoda*) are chiefly known to us in this migratorial nymphal condition." The individual mite, a "nympha pedunculata," is attached to the beetle by an "anal pedicel" formed of excretions (fig. 2—AP).

LITERATURE CITED

Banks, N. 1905. A treatise on the Acarina, or mites. Proc. U. S. National Museum 28(1382): 1–114.
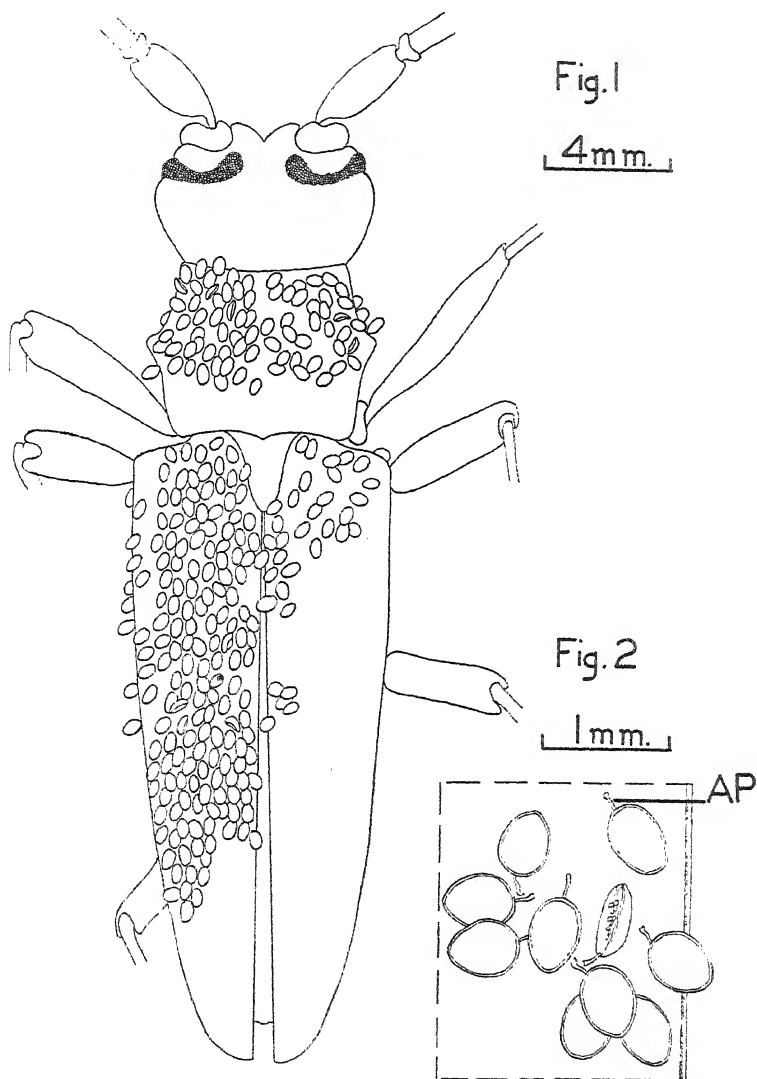
FIG. 1. Dorsal view of *Monochamus notatus* and its covering of mites.
FIG. 2. Portion of inner border of left elytron showing attached mites.
AP—anal pedicel

OBITUARIES

LELAND OSSIAN HOWARD, (1857–1950), Honorary Fellow and charter member of the Entomological Society of America, internationally known American biologist, writer and administrator, and Chief of the Bureau of Entomology, U. S. Department of Agriculture for 33 years, was born June 11th, 1857, at Rockford, Illinois. He was oldest child of Ossian Gregory Howard and Lucy Dunham [Thurber] Howard. While the child was still in infancy, the parents removed to Ithaca, New York, where the growing child later attended school. During boyhood he attended the Ithaca Academy and a Latin preparatory school. In September, 1873, he became a student at Cornell University, and during the four years that followed at that institution he not only made excellent progress with his studies, but was particularly fortunate to come under the influence of some outstanding scientists, among them Dr. Charles Valentine Riley with whom in after years he was to become very closely associated. On November 13th, 1878, Dr. Riley appointed young Howard, then newly graduated from Cornell, and age 21, to be his assistant in entomological work in Federal Agricultural service in Washington—the beginning of a period of Government connection that continued for over 49 years, and, through the subsequent work and influence of this individual, comprised one of the most important epochs thus far in American economic entomology. Dr. Riley resigned in 1879 and was succeeded for two years by Professor John Henry Comstock. At the end of that period, however, he returned to Cornell and Dr. Riley was reappointed to his former position and remained as Chief until his final resignation in June, 1894, from the then Division of Entomology. It was at that time that L. O. Howard, then age 37, was appointed to take the vacant place.

It is of profound significance that when he became Chief in 1894 the total annual appropriation for Federal entomological work of all kinds was only $30,000. When he retired from the position of Chief 33 years later in 1927 at age 70, the annual appropriation was $3,000,000. Here for once figures are eloquent and do not need to be enlarged upon. However, the story of those years is long and complex and the scope and brevity of this notice does not include more than mere mention of some of the more outstanding phases of the work performed. During the ten years that followed from 1894 to 1904, there occurred three events that fixed the attention of the whole country upon the importance of entomological work: the discovery of the gypsy moth in Massachusetts in 1889; the discovery of the San Jose scale in the United States in 1893; and the discovery of the Mexican cotton boll weevil in Texas in 1894. The research work performed on these problems was in addition to that on other insect pests being studied, and, obviously required considerable additional funds and increased personnel, and these resulted in substantial growth of every phase of the organization. In 1904 there was put into effect by Congress the plan of organization of federal entomological work by which separate units were established for investigation of pests affecting the various host plants, such as field crops, truck crops and the like, a set-up that still remains in effect at the present time in modified form in the Bureau. It was also on July 1st, 1904, that the entomological work of the Department was raised to Bureau status.

A notable addition to the striking events of the last decade of the nineteenth century was a discovery by Ross in 1898 of the carriage of malaria by Anopheles mosquito—one of the most far-reaching and revolutionary discoveries ever made up to that time in the etiology of disease, since malaria was practically a worldwide malady. Within a short time thereafter the work of Reed, Carroll, Lazear and others demonstrated that without doubt yellow fever also is mosquito-borne and is transferred only by a certain species of mosquito, and thus Medical entomology presently became a most important field of investigation and demanded intimate co-operation of the pathologists and entomologists, and in all these

Dr. Howard had an honorable part. Under his immediate supervision or in co-operation with other workers, extensive series of tests were carried on with various domestic insects in relation to disease and the results received world-wide publicity and much active discussion.

The practical use of predatory and parasitic insects in the control of injurious pests was under consideration for many years and tentative experiments had been made from very early times. Much work of this sort was carried on by Dr. Howard and his assistants, and was in some instances on extensive scale, notably that with the European and Japanese enemies of the gypsy and brown tail moths, and had a very considerable degree of success. Similar plans also were developed by him on a large scale in connection with work against the Japanese beetle, the European corn borer and others. All these and his other activities in medical entomology took him year after year on numerous and often repeated trips to Europe and other countries in course of their development.

From 1896 to 1930 Dr. Howard was recognized by being given degrees from several institutions. These included the Ph. D., M. D., LL. D., and D. Sc. More than 900 publications came from the pen of Dr. Howard during his creative years, including not only his official reports and bulletins and a veritable stream of periodical articles, but also several books. Among the more important of these were "The Insect Book," 1901; "Mosquitoes," 1901; "The House Fly," 1911; "Mosquitoes of North America," 1912–17, (4 vols., joint authorship with H. G. Dyar and Frederick Knab); "History of Applied Entomology," 1930; "The Insect Menace," 1931; and "Fighting the Insects: An Autobiography," 1933. In addition to all the activities previously mentioned, he was also identified with the following: Honorary Curator, Division of Insects, U. S. National Museum since 1895; Consulting Entomologist, U. S. Public Health Service since 1904; Senior Entomologist with grade of Senior Surgeon, Reserve of U. S. Public Health Service, since 1919; Member of Committee on Agriculture of National Council of Defense, 1917; Chairman of subcommittee on Medical Entomology, National Research Council, 1917; Trustee of Cornell University, 1900–1905; Permanent Secretary, A. A. A. S., 1898–1920—22 years; President American Association of Economic Entomologists, 1894; President of Biological Society of Washington, 1897–98; President of Cosmos Club, 1909; President of Washington Academy of Sciences, 1916; President of A. A. A. S., 1920; Honorary President of Entomological Society of Washington for many years; Vice-President International Congress of Agriculture, Paris, 1923; Honorary President International Conference of Phytopathologists and Economic Entomologists, Holland, 1913; Chairman, Pan Pacific Food Conservation Congress, Honolulu, 1924; President of Section of Economic Zoology, International Congress of Zoology, Budapest, 1927; and President of International Congress of Entomology, Ithaca, N. Y., 1929. In addition to the above, he likewise was member of the following: American Philosophical Society; National Academy of Sciences; Fellow of American Academy of Arts and Sciences. He was also honorary member of many foreign scientific societies. Then too, he was decorated Chevalier Legion of Honor, (France), 1925, Officier, 1929. He was made Officier of Agricultural Merit (France) 1925, and was Medalist of the Holland Society of New York, 1924. He also received second $5,000 Capper Award and gold medal in 1931 for distinguished service in Agriculture.

Dr. Howard was married on April 28th, 1886, to Miss Marie T. Clifton of Washington. Of that union there were born three daughters: Lucy Thurber, Candace Leland (Mrs. Edward D. Payne), and Janet Moore Howard. The mother died in 1926.

His membership in the Cosmos Club, an internationally known organization of scientists, writers, artists and the like in Washington, was, as he himself has written, not only a "constant source of delight, but of the most enormous educational value." This membership beginning in 1886 continued for over sixty-four years and terminated only with his death, at which time he was the oldest member of the Club, both in years and in length of membership.

From the time of Dr. Howard's retirement in 1927 as Chief of Bureau, he served four years, until 1931, as consultant to the Department in matter concerning biological control of insect pests. He retired from Government service on June 30th, 1931, at age 74. During the 17 years that followed, he resided for a time in Washington, then moved to France, and still later he returned to America and

spent his last years in New York State. He died May 1st, 1950, at his home in Bronxville, New York. At time of death he lacked only a few weeks being 93 years of age.

Dr. Howard himself has given perhaps one of the best summations of his life when in the concluding lines of his Autobiography he says: "I have led a long and happy life, and I have been very lucky to have been able to spend it all working in entomology. Surely the world knows a great deal more today about our rivals, the insects, than it did when I was a youngster. I am thankful that fate has given me a chance to see this great progress, and to watch it from the inside, and to be one of the workers."—J. S. WADE.

HERBERT SPENCER BARBER, (1882–1950), internationally-known entomologist of the U. S. Department of Agriculture's Bureau of Entomology and Plant Quarantine, died of a heart attack on June 2 at his home, 644 6th St., N. W., Washington, D. C.

Mr. Barber's knowledge of the biology and classification of beetles had few equals. His long and broad experience in both laboratory and field was coupled with an unusual memory for details. He was an authority on weevils, leaf beetles, and seed beetles, many of which are of extreme importance to an agricultural economy.

His knowledge of entomology, and especially of entomological techniques, was so broad that many entomologists in this country made special effort to discuss their scientific studies with Mr. Barber before they were completed. Many of the younger entomologists of today owe to him much of their basic philosophy in respect to science.

Mr. Barber was born April 12, 1882, at Yankton, S. D. He was educated in the public schools of Orlando, Fla., and Washington, D.C. He met the famous coleopterist, Dr. E. A. Schwarz, while still a high school student, and in September, 1898, became a preparator of insects under Dr. Schwarz' direction. In 1902 he entered government service with the then Bureau of Entomology of the U. S. Department of Agriculture. In 1908 he was assigned to the Division of Insect Identification of the Bureau quartered at the U. S. National Museum, and served as a specialist in this Division until he died.

His interests were many and varied. He traveled and collected insects extensively in this country and in Guatemala and Mexico. He knew most of the kinds of birds, fish, flowers, shrubs, trees, and other living things in this area. Mr. Barber's interest and devotion to his chosen profession permeated his every activity and fostered an interest in all things associated with outdoor life. He made full use of every opportunity to explore the woods and streams in many sections of this country. He took special delight in sharing his knowledge and love of the outdoors with others, particularly with children, many of whom acquired through him a lifelong interest in these activities.

He was a charter member of the Entomological Society of America; and also a member of the American Association for the Advancement of Science, American Association of Economic Entomologists, Entomological Society of Washington, Washington Academy of Sciences, Biological Society of Washington, Washington Biological Field Club, and the Potomac Appalachian Trail Club.—D. G. HALL.

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All new names are printed in *italics*.

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MAILING DATES FOR 1950 ISSUE OF THE ANNALS

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